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Science Bulletin - Vol. XXVII - Part I
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# SCIENCE BULLETIN

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RESEARCH BY MEMBERS OF THE
UNIVERSITY OF KANSAS

VOLUME XXVII, PART I

UNIVERSITY OF KANSAS PUBLICATIONS

LAWRENCE, NOVEMBER 1, 1941

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PRINTED BY KANSAS STATE PRINTING PLANT
W. C. AUSTIN, STATE PRINTER
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# CONTENTS OF VOLUME XXVII, Pt. I.


| No. | | PAGE |
|---|---|---|
| 1. | Weights and Linear Dimensions of the Skull and of Some of the Long Bones of the Mallard Duck (*Anas platyrhynchos platyrhynchos*). *Homer B. Latimer* and *Henry P. Wager* | 5 |
| 2. | Apparatus for Measurements on Single-celled Organisms. *C. Wolfson* | 19 |
| 3. | The Effects of Drugs Administered Daily in Therapeutic Doses Throughout the Life Cycle of Albino Rats. *Lloyd L. Boughton* and *O. O. Stoland* | 27 |
| 4. | A New Anuran from the Middle Miocene of Nevada. *Edward H. Taylor* | 61 |
| 5. | A New Pycnodont Fish from the Upper Cretaceous of Rooks County, Kansas. *Claude W. Hibbard* and *Allen Graffham* | 71 |
| 6. | Paleoecology and Correlation of the Rexroad Fauna from the Upper Pliocene of Southwestern Kansas, as Indicated by the Mammals. *Claude W. Hibbard* | 79 |
| 7. | Herpetological Miscellany, No. II. *Edward H. Taylor* | 105 |
| 8. | New Amphibians from the Hobart M. Smith Mexican Col- | |



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Museum of Comparative Zoology
JAN 13 1942
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E - NH-L

12,955

Museum of Comparative Zoology
JAN 13 1942
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# CONTENTS OF VOLUME XXVII, Pt. I.


| No. | | PAGE |
|---|---|---|
| 1. | Weights and Linear Dimensions of the Skull and of Some of the Long Bones of the Mallard Duck (*Anas platyrhynchos platyrhynchos*). *Homer B. Latimer* and *Henry P. Wager* | 5 |
| 2. | Apparatus for Measurements on Single-celled Organisms. *C. Wolfson* | 19 |
| 3. | The Effects of Drugs Administered Daily in Therapeutic Doses Throughout the Life Cycle of Albino Rats. *Lloyd L. Boughton* and *O. O. Stoland* | 27 |
| 4. | A New Anuran from the Middle Miocene of Nevada. *Edward H. Taylor* | 61 |
| 5. | A New Pycnodont Fish from the Upper Cretaceous of Rooks County, Kansas. *Claude W. Hibbard* and *Allen Graffham* | 71 |
| 6. | Paleoecology and Correlation of the Rexroad Fauna from the Upper Pliocene of Southwestern Kansas, as Indicated by the Mammals. *Claude W. Hibbard* | 79 |
| 7. | Herpetological Miscellany, No. II. *Edward H. Taylor* | 105 |
| 8. | New Amphibians from the Hobart M. Smith Mexican Collections. *Edward H. Taylor* | 141 |
| 9. | The Genus Telmatometra Bergroth (Hemiptera-Gerridae). *Eugene E. Kenaga* | 169 |
| 10. | A Contribution to the Taxonomy of the Subfamily Issinae in America, North of Mexico (Fulgoridae, Homoptera). *Kathleen C. Doering* | 185 |

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XXVII] NOVEMBER 1, 1941 [No. 1

# Weights and Linear Dimensions of the Skull and of Some of the Long Bones of the Mallard Duck (*Anas platyrhynchos platyrhynchos*)

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Department of Anatomy, University of Kansas

ABSTRACT: The weights of the skull and of the six pairs of long bones from 32 males and 26 females are more variable than the linear dimensions of the same bones and the thirteen dimensions of the skull. These weights and linear dimensions are more variable in the females. The linear dimensions of the six long bones are more variable in the females, but they form the most constant group of measurements in both sexes. The transverse dimensions of the skull are more variable than the longitudinal. The skull length, height and width are among the most constant measurements of the skull in both sexes and hence their general use is justified by these data.

All of the weights and all but two of the linear dimensions are significantly greater in the males.

The correlations of the skull weight and skull length with the various weights and linear dimensions are all positive except in two cases and these two dimensions are not very reliable. The correlations are, on the average, higher in the females although the variability is greater in the females. The skull length is a better criterion of both the weights and the linear dimensions in both sexes than is the skull weight.

The asymmetry in weight and length of the paired bones is somewhat more evident than in some of the other skeletal material studied and yet no type of asymmetry is recognizable. In the ponderal measurements, the female radius is the most asymmetrical, with the right radius heavier more frequently. The most marked asymmetry in the linear dimensions is found in the tibiofibula, with the longer bone found on the right side most frequently in both sexes.

## INTRODUCTION

THE literature on the quantitative anatomy of the various forms of animal life is gradually increasing, but so far as is known no quantitative study of the duck skeleton has been made. The study of the coot skeleton by Engels ('38) comes the closest to this study of the duck skeleton. As in the four preceding papers of this series, the weights of the individual specimens or even the entire skeletal weights are not available. Some of the bones were broken and a few of the bones were missing and so the weight of the entire skeletons could not be determined and hence we are unable to correlate the individual bone weights with either body weight or skeletal weight. The same general plan used in the earlier papers will be followed, or the average weights of six of the long bones, the skull and the mandible will be presented, together with thirteen dimensions of the skull, the lengths of the same six long bones and four other skeletal dimensions. The variability of each of these measurements as well as the sex difference will be studied and then the weights and linear dimensions will be correlated with skull weight and with skull length in both the males and in the females. Last of all, the asymmetry in weight and in length of the six pairs of long bones will be given.

## MATERIALS AND METHODS

The skeletons of 58 mallard ducks, 32 males and 26 females, from the Natural History Museum of the University of Kansas were used in this study. A few of the skeletons had one or more bones broken so that they could not be weighed or measured, but as many as possible were weighed and measured. Most of these skeletons were collected in Kansas, but a few were collected in Colorado and a smaller number in Nebraska. These specimens came from a wider range than the other skeletal groups previously reported, but with the extensive migration of the duck this should in no way decrease the value of this skeletal collection. These skeletons were prepared under the supervision of Mr. C. D. Bunker in the same excellent manner as the skeletons of the four other groups of animals previously reported.

Each of the paired bones was weighed and measured separately and the sum of the weights of the two bones is used in all but table 3, and the average of the two linear dimensions is used in all cases except in table 3. The bones were weighed first and the bone of each pair picked up first was weighed or measured first so that there

might not be any regular sequence which might tend to develop a personal bias in making the measurements. The weighing was done before the measurements were made to avoid handling the bones as much as possible before they were weighed. The bones of each skeleton were stored in a separate pasteboard box and kept in a dry room for some time previous to making the weights. They were not oven dried.

All of the weights were made on a chemical balance sensitive to one-tenth of a milligram and the linear dimensions were made with a vernier caliper reading to one-tenth of a millimeter. The weights were recorded only to the nearest milligram and the linear dimensions to tenths of a millimeter. The junior author made all of the linear measurements and the senior author made the ponderal measurements and is responsible for the statistical data and for the completion of the paper.

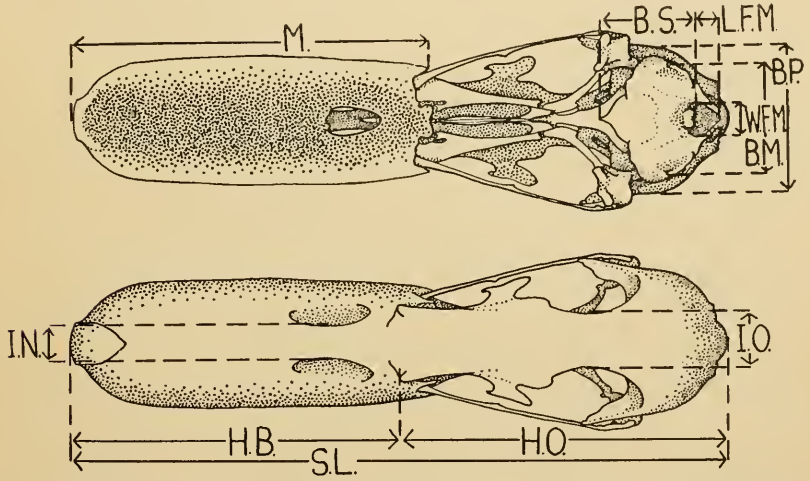


FIG. 1. Drawings of the ventral and dorsal aspects of the skull to show the methods of making the eleven measurements. The methods used in making the additional measurements are described in the text.

M., Length, mandible
B.S., Length, basion-spine sphenoid
L.F.M., Length, foramen magnum
W.F.M., Width, foramen magnum
B.P., Biparietal width
B.M., Bimastoid width
S.L., Skull length
H.B., Length, hinge-tip of beak
H.O., Length, hinge-occiput
I.N., Internasal width
I.O., Interorbital width

The method of measuring eleven of the dimensions of the skull is shown in Fig. 1. In addition to these the skull height was measured by holding the fixed arm of the caliper along the base of the skull and bringing the movable arm gently down until it touched

the top of the skull. The length of the mandible is its maximum length from the anterior tip to the most posterior part of the angle on the left side with the back of the caliper held parallel to the left side of the mandible. The length of the coracoid and of the six pairs of long bones is the maximum length with the long axis of the bone held parallel to the back of the calipers. The length of the sternum is the maximum length of the keel from the anterior tip to the posterior mid point of the body of the sternum and the keel which is fused with it. The sternal height is the height of the anterior part of the keel with the anterior border of the keel held parallel to the back of the caliper. It is really the height of the keel plus the thickness of the body of the sternum at this point. The biacetabular diameter is the minimum transverse diameter measured from the notch in the anterosuperior border of the acetabulum.

All of the statistical work was carefully checked and the formulae used are the ones usually so employed. They are given by Dunn ('29). All of the computations were carried to more decimal places than given in the tables.

We wish to express our most hearty thanks to Mr. C. D. Bunker, who has so willingly loaned us this excellent series of skeletons for this study.

## AVERAGES AND VARIATION

The average weight in grams and the average linear dimensions for the males and for the females and the coefficients of variation are given in table 1. The last column of this table gives the significant ratio, or the difference between the dimensions of the male and female divided by the probable error of this difference. As is to be expected, the weights are more variable than the linear measurements, which involve but one dimension. In the male duck skeletons, the skull weight is next to the lowest in variability. The tibiofibula is the least variable in weight and the ulna is the most variable. In the females, the skull weight is the second in variability, being surpassed only by the weight of the tarsometatarsus. The radius is the least variable of the weights of the female bones. The average of the coefficients of variation for the weights is 11.48 for the males and 14.34 for the females, or the weights in the females are about 25 percent more variable.

The linear dimensions are given in the second half of this table and they are less variable. The last three dimensions were made by the Museum staff and they were recorded for one-half or less than one-half of the specimens, and because of their limited number they

should not carry as much weight as the measurements made on a larger number of specimens. The numbers of the male specimens measured for the last three dimensions in table 1 are in the order given in the table, 16, 15 and 14, and for the females, respectively, 12, 9 and 9 specimens. The first 23 linear dimensions, or all of the linear measurements except the last three, have average coefficients of variation of 4.23 percent for the males and 4.39 percent for the females, or the females are nearly four percent (3.86%) more variable than the males. The average of the coefficients for the thirteen skull dimensions alone is 4.75 for the males and 4.66 for the females. This average and the average of the skull lengths are the only average coefficients of variation which are smaller in the females, or on the whole the skull of the female duck is very slightly less variable than the male skull, and this, as will be shown later, is due to the more constant longitudinal dimensions of the female skull. The skull length and skull height in the males are, respectively, third and fourth from the most constant. The two dimensions having the lowest coefficients are the biparietal diameter and occiput-hinge dimension. In the females, the occiput-hinge length is the most constant followed in order of increasing variability by the skull height, biparietal diameter and the skull length. The coefficient of 2.62 percent for the female occiput-hinge dimension is the lowest coefficient for any of the skull dimensions in both sexes.

The most variable dimension is likewise found in the female skull and it is the internasal diameter with a coefficient of 10.52 for the females and 8.24 for the males. It is likewise the most variable dimension in the male skull. The internasal and the interorbital diameters are the two most variable dimensions in the skulls of both sexes. In the mourning dove skull (Latimer and Asling, '38) the most variable dimension was the interorbital width and likewise in the red-tailed hawk (Latimer, '38) the interorbital and internasal diameters are markedly variable in both sexes. It was suggested in the report on the hawk skeleton that these two measurements are made from thin edges of bone and hence may vary without any significant effect on the strength of the skull as the central parts of the bone maintain its strength.

The seven longitudinal dimensions of the skull in both sexes were compared with the five transverse dimensions to see whether the lengths or the widths were more variable. In the males the averages of the coefficients are 4.20 for the lengths and 5.73 for the transverse dimensions, or the transverse dimensions of the male skull

are about 36 percent more variable. The similar averages for the female skulls are 3.94 for the lengths and 5.99 for the widths or in the females the transverse dimensions are, on the average, 52 percent more variable. The averages of the coefficients of variation of the thirteen skull dimensions, for both sexes, were determined, next the coefficients of the ten linear dimensions including the six long bones, and lastly for the six long bones and these were found to be as follows:

| | Males | Females |
|---|---|---|
| 13 dimensions of the skull | 4.75% | 4.66% |
| 10 remaining dimensions | 3.54% | 4.03% |
| 6 long bones | 2.77% | 3.69% |

In general, the weights are more variable than the linear dimensions and they are more variable on the average in the females. The linear dimensions of the skull are the only coefficients which have a greater average in the male. The transverse dimensions of the skull are more variable than the longitudinal dimensions in both sexes. The linear dimensions of the six long bones are more variable in the females, but in both sexes they form the most constant group of measurements. The skull weight is a very constant measurement in the male duck skeletons, but in the females it is one of the most variable and hence less reliable. The skull length and height and the skull width (biparietal) are all among the most constant dimensions of the skull in both sexes and hence their general use is justified by these data.

The last column of table 1 shows that all of these measurements, both ponderal and linear, are significantly greater in the male ducks with the exception of the interorbital diameter, which has a significant ratio of 1.10 and the length of the tail. These are measurements on which but little reliance can be placed and so we are justified in making the statement that both in weight and in the linear dimensions the parts of the duck skeletons studied are statistically greater in the male. In addition to the ratios shown in table 1, the percentage differences between the males and the females were determined. The weights in the males range from 11.10 percent (ulna) to 19.99 percent (femur) heavier in the males or an average difference of 14.83 percent. The skull dimensions range from 1.42 percent (interorbital) to 8.42 percent (hinge-tip of beak) greater in the males, or an average of 5.35 percent. The remaining thirteen linear dimensions average 5.65 percent greater in the males with a range from 3.43 percent (radius) to 9.71 percent for the total length or 8.78 percent for the sternal height.

Comparing these data on the duck skeleton with the data given in the earlier papers on the two bird skeletons, it is evident that the average variability of the weights of the skull and of the long bones are lowest in the mourning dove, next in the mallard duck and the most variable in the red-tailed hawk. As has been stated above, the females are more variable in the duck skeletons, but the males are more variable in the hawks. The averages of the coefficients of variability of the linear dimensions of the skull in the forms for which these data are available, are lowest in the turkey hen (Latimer and Rosenbaum, '26) and in increasing order of variability are: the single-comb white Leghorn chicken (Schneider and Dunn, '24), the fox sparrow (Linsdale, '30), the mallard duck, the red-tailed hawk and most variable of all, the mourning dove. Two dimensions of the skull of the turkey and of the chicken were made, four of the fox sparrow skull, twelve for the mourning dove, thirteen for the mallard duck and fourteen for the hawk skulls. Comparing these groups of bird skeletons for the average length of the long bones, we find the lowest variability in the fox sparrow and in order of increasing variability are: the mourning dove, the mallard duck, the coot (Engels, '38), the turkey hen, the red-tailed hawk and very slightly more variable, the Leghorn chicken. Four long bones were measured in the chickens and all six long bones in all of the others. Statistical data are given for the California road runner (Larson, '31) and the woodpeckers (Burt, '31), but the coefficients of variation are not given. These averages show that the skeletal measurements of the mallard duck fall well within the range of variability found in other bird skeletons.

## CORRELATIONS

To see how well the skull length and the skull weight predict the other measurements of these skeletons, the various weights and the linear dimensions were correlated with the skull weight and the skull length and these correlations are given in table 2. All but two of these correlations are positive, but many of the positive correlations are so low that they are not significant. All of the weights correlated with either skull weight or skull length are positive. The weights correlated with skull weight average 0.395 in the males and 0.607 in the females and the similar averages with the skull length are, respectively, 0.483 and 0.554, or the correlations are higher in the female ducks. In the males, the higher average correlation for the weights is found with the skull length and in the females, the higher average is with the skull weight. The highest correlations in both sexes are the weight of the mandible with skull weight, and the sec-

ond best correlations are between the weight of the mandible and the skull length. It is interesting to see that in both sexes and with both skull weight and with skull length, the correlations of the weights of the three bones of the wing are always highest with the humerus, lower with the radius and lowest with the ulna. This arrangement of the correlations with the linear dimensions of the three wing bones is not found in any case. A similar decreasing correlation in bone weight from proximal to distal bone of the leg is found in the correlations with the female skull weight and skull length. In the males the correlations of the bone weights increase in value from proximal to distal bone of the leg. There seems to be no uniformity in the correlations of the linear dimensions of the leg bones.

The average of the positive correlations for all of the linear dimensions with both skull weight and skull length in the males and with skull length in the females is higher than the average of the similar correlations of the weights. The only negative correlations found in this table are the internasal diameter correlated with both skull weight and skull length in the males. This dimension in the females is not significantly correlated with skull weight or skull length, but the correlations are not negative. With the exception of two dimensions (bimastoid and coracoid) all of the linear dimensions in the males are better correlated with the skull length than with the skull weight. This is true for the longitudinal and for the transverse dimensions alike. In the females the skull height, the sternal height and the transverse skull dimensions, with the exception of the bimastoid diameter, are better correlated with skull weight, and the linear dimensions of the long bones are better correlated with the skull length.

There are three correlations in the males and three in the females above 0.9. These are all linear dimensions of the skull correlated with skull length, and they are the length of the mandible, the length of the maxilla and the length from the hinge to the tip of the beak. The lengths of the mandible and maxilla are the two longest dimensions of the skull except the total length, and they form, respectively, 92 and 54 percent of the skull length in both sexes. The hinge-tip of beak dimension forms a little less than 50 percent of the skull length. All of these are relatively large parts of the total skull length and it is but natural that they should have high correlations with the skull length. The occiput-hinge dimension is slightly longer in both sexes than the hinge-tip of beak dimension and yet its correlations with the skull length are lower, being 0.875 in the males and 0.881 in the females.

The average of all of the correlations of the linear dimensions is higher in the females or the weights and linear dimensions are better correlated with both skull weight and skull length in the females. The skull length is also a better index, on the average, than is the skull weight except for the transverse dimensions of the skull in the females. The question arose as to whether the bones of the wing or of the leg were better correlated with these two dimensions of the skull. The average of the linear correlations of the bones of the two extremities in the male correlated with skull weight were exactly alike, but the lengths of the bones of the leg were a little better correlated with skull length than were the wing bones. In the females the lengths of the wing bones were better correlated with both measurements of the skull.

In general the skull length is a better criterion of the weights and linear dimensions than is the skull weight and the correlations are higher in the females than in the males. Most of the skull widths in the females, however, are better correlated with the skull weight than with skull length. It has been shown above that the females have a slightly higher average coefficient of variability and yet table 2 shows that the two skull dimensions are better correlated with the weights and linear dimensions in the females.

The correlations in the duck are about the same as the average for the turkey (Latimer, '27), and the hawk (Latimer, '38), but better than in the mourning dove (Latimer and Asling, '38). Two correlations in the chicken (Schneider and Dunn, '24) are very similar to these correlations in the duck. The average of the correlations of both the weights and the linear dimensions in these birds are all lower than the similar average correlations for the muskrat (Latimer and Riley, '34), the skunk (Latimer, '37) and for the correlations of some external measurements in the cat (Latimer, '36). This would indicate that these bird skeletons are less well correlated with these skull measurements than are the skeletons of the three mammals.

## ASYMMETRY

In the preceding tables the average of the lengths, and the sum of the weights of the right and left bones are given, but in table 3 the asymmetry in length and in weight of the paired bones is sl own. As has been stated previously, some of the individual bones were broken or injured so that they could not be weighed or measured, and so the number of skeletons with both bones complete is given. The percentage frequency of a heavier or longer right bone, or left bone, or bones of equal length or weight are given in terms of per-

centage of the total number of pairs of bones studied and with the number of cases given in the first column the actual number of cases can easily be determined. The percentages give a better idea of the frequencies than the actual numbers.

The degree of asymmetry in some of the bones such as the tibiofibula, seems to be pronounced and many of these weights and linear dimensions are more asymmetrical than in the preceding skeletons studied. It must be remembered that many of these variations are so small that they would not be physiologically significant. The highest case of asymmetry is found in the linear dimension of the male tibiofibula and the second highest in the same bone in the female and yet the weights of these bones in both sexes are divided 50-50. Weakley and Dustman ('39) in a study of the asymmetry in the three bones of the wing and the femur and tibia of the 35-day-old chick, report all but the femur heavier more frequently on the left side. Kopec ('38), however, finds no clearly defined asymmetry in the leg bones of the mouse.

While these bones seem to be more asymmetrical than the bones of the mourning dove and the hawk and also the paired bones of the mammals studied, yet no explanation is available, other than that of fortuitous variation.

## SUMMARY

The weights of the skull and of the six pairs of long bones are more variable than the linear dimensions of the same pairs of bones and the thirteen dimensions of the skull. The averages of these weights and linear dimensions are more variable in the females. The linear dimensions of the six long bones are more variable in the females, but they form the most constant group of measurements in both sexes. The transverse dimensions of the skull are more variable than the longitudinal. The skull length, height and width (biparietal diameter) are among the most constant of the dimensions of the skull in both sexes and hence their general use is justified by these data.

All of the weights and all but two of the linear dimensions (interorbital diameter and tail length) are significantly greater in the males.

The correlations of the skull weight and skull length with the various weights and linear dimensions are all positive except in two cases and these two dimensions are the most variable of all of the linear dimensions and are not very reliable. The correlations are on the average higher in the females, although the variability is

greater in the females. The skull length is a better criterion of both the weights and the linear dimensions in both sexes than is the skull weight.

The asymmetry in weight and length of the paired long bones is somewhat more evident in these duck skeletons and yet no type of asymmetry is recognizable. In weight, the female radius is the most asymmetrical, with the right radius heavier more frequently. The most marked asymmetry in the linear dimensions is found in the tibiofibula with the longer bone found on the right side most frequently in both sexes.

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TABLE 1

*Average measurements, coefficients of variation and significant ratios*

| | Males. | | Females. | | Difference. |
|---|---|---|---|---|---|
| | Average weight in grams. | Coefficient of variation. | Average weight in grams. | Coefficient of variation. | P. E. diff. |
| Skull | 4.722 ±0.058 | 9.46 ±0.88 | 4.080 ±0.101 | 17.59 ±1.78 | 5.51 |
| Mandible | 2.118 ±0.030 | 11.27 ±1.03 | 1.810 ±0.039 | 15.69 ±1.55 | 6.26 |
| Humerus | 7.792 ±0.098 | 10.20 ±0.90 | 6.695 ±0.100 | 10.89 ±1.06 | 7.84 |
| Radius | 1.709 ±0.025 | 11.82 ±1.04 | 1.536 ±0.020 | 9.92 ±0.94 | 5.40 |
| Ulna | 4.093 ±0.075 | 14.95 ±1.33 | 3.684 ±0.069 | 14.08 ±1.34 | 4.01 |
| Femur | 2.125 ±0.030 | 11.47 ±1.00 | 1.771 ±0.035 | 14.82 ±1.42 | 8.63 |
| Tibiofibula | 3.477 ±0.037 | 8.53 ±0.75 | 3.020 ±0.058 | 13.84 ±1.36 | 6.64 |
| Tarsometatarsus | 1.699 ±0.030 | 14.11 ±1.25 | 1.517 ±0.037 | 17.92 ±1.78 | 3.82 |
| | Average length in millimeters | | Average length in millimeters. | | |
| Skull height | 27.69 ±0.13 | 3.70 ±0.33 | 26.63 ±0.11 | 3.05 ±0.29 | 6.22 |
| Skull length | 114.71 ±0.53 | 3.72 ±0.33 | 107.58 ±0.47 | 3.28 ±0.31 | 10.00 |
| Occiput-hinge | 58.38 ±0.25 | 3.32 ±0.30 | 55.64 ±0.19 | 2.62 ±0.24 | 8.73 |
| Hinge-tip of beak | 57.04 ±0.35 | 4.94 ±0.44 | 52.61 ±0.30 | 4.37 ±0.41 | 9.61 |
| Basion-spine sphenoid | 16.33 ±0.10 | 4.76 ±0.44 | 15.68 ±0.088 | 4.08 ±0.39 | 4.88 |
| Length maxilla | 62.50 ±0.38 | 4.79 ±0.43 | 57.79 ±0.32 | 4.19 ±0.39 | 9.48 |
| Internasal | 3.88 ±0.040 | 8.24 ±0.73 | 3.58 ±0.050 | 10.52 ±0.99 | 4.69 |
| Interorbital | 9.99 ±0.096 | 7.82 ±0.68 | 9.85 ±0.084 | 6.47 ±0.61 | 1.10 |
| Biparietal | 26.10 ±0.101 | 3.09 ±0.27 | 25.53 ±0.10 | 3.11 ±0.29 | 4.03 |
| Bimastoid | 21.07 ±0.13 | 4.66 ±0.42 | 20.05 ±0.12 | 4.44 ±0.42 | 6.05 |
| Foramen magnum, length | 7.84 ±0.040 | 4.12 ±0.37 | 7.42 ±0.059 | 5.77 ±0.56 | 5.89 |
| Foramen magnum, width | 7.18 ±0.044 | 4.85 ±0.43 | 6.94 ±0.052 | 5.42 ±0.52 | 3.52 |
| Length mandible | 105.78 ±0.49 | 3.74 ±0.33 | 98.77 ±0.43 | 3.30 ±0.31 | 10.75 |
| Humerus | 95.71 ±0.29 | 2.51 ±0.22 | 91.44 ±0.43 | 3.45 ±0.33 | 8.23 |
| Radius | 75.46 ±0.21 | 2.25 ±0.19 | 72.96 ±0.30 | 3.12 ±0.29 | 6.83 |
| Ulna | 81.45 ±0.22 | 2.23 ±0.19 | 78.71 ±0.32 | 3.11 ±0.29 | 7.06 |
| Femur | 52.10 ±0.17 | 2.74 ±0.23 | 49.80 ±0.30 | 4.61 ±0.43 | 6.67 |
| Tibiofibula | 87.99 ±0.35 | 3.32 ±0.29 | 84.55 ±0.41 | 3.53 ±0.34 | 6.38 |
| Tarsometatarsus | 46.18 ±0.20 | 3.54 ±0.30 | 43.86 ±0.26 | 4.29 ±0.41 | 7.07 |
| Coracoid length | 57.03 ±0.24 | 3.51 ±0.30 | 53.53 ±0.30 | 4.26 ±0.40 | 9.11 |
| Sternal length | 105.63 ±0.59 | 4.62 ±0.40 | 98.82 ±0.50 | 3.86 ±0.36 | 8.81 |
| Sternal height | 30.12 ±0.15 | 4.19 ±0.36 | 27.69 ±0.14 | 3.96 ±0.37 | 12.65 |
| Biacetabular | 28.88 ±0.22 | 6.53 ±0.55 | 27.59 ±0.23 | 6.14 ±0.59 | 4.05 |
| Total length | 590.31 ±2.66 | 2.59 ±0.31 | 538.08 ±5.14 | 4.70 ±0.65 | 9.02 |
| Tail length | 104.60 ±1.18 | 6.27 ±0.79 | 100.11 ±2.20 | 9.20 ±1.52 | 1.80 |
| Wing spread | 283.21 ±4.55 | 8.58 ±1.12 | 264.11 ±2.36 | 3.74 ±0.61 | 3.73 |

TABLE 2

*Correlations*

| | Males. | | Females. | |
|---|---|---|---|---|
| | Correlations with skull weight. | Correlations with skull length. | Correlations with skull weight. | Correlations with skull length. |
| **Weights in grams.** | | | | |
| Skull | ..... | +0.540 ±0.092 | ..... | +0.775 ±0.056 |
| Mandible | +0.858 ±0.047 | +0.667 ±0.072 | +0.894 ±0.029 | +0.814 ±0.046 |
| Humerus | +0.450 ±0.104 | +0.620 ±0.078 | +0.675 ±0.078 | +0.749 ±0.060 |
| Radius | +0.332 ±0.116 | +0.561 ±0.087 | +0.554 ±0.097 | +0.514 ±0.097 |
| Ulna | +0.255 ±0.121 | +0.549 ±0.089 | +0.323 ±0.126 | +0.196 ±0.127 |
| Femur | +0.088 ±0.129 | +0.120 ±0.126 | +0.634 ±0.084 | +0.552 ±0.092 |
| Tibiofibula | +0.312 ±0.117 | +0.391 ±0.108 | +0.632 ±0.086 | +0.444 ±0.111 |
| Tarsometatarsus | +0.473 ±0.101 | +0.417 ±0.105 | +0.539 ±0.102 | +0.384 ±0.117 |
| **Linear dimensions in millimeters.** | | | | |
| Skull height | +0.566 ±0.088 | +0.630 ±0.076 | +0.577 ±0.094 | +0.464 ±0.104 |
| Skull length | +0.540 ±0.092 | ..... | +0.775 ±0.056 | ..... |
| Occiput-hinge | +0.555 ±0.090 | +0.875 ±0.030 | +0.757 ±0.060 | +0.881 ±0.030 |
| Hinge-tip of beak | +0.467 ±0.102 | +0.983 ±0.0044 | +0.720 ±0.068 | +0.960 ±0.010 |
| Basion-spine sphenoid | +0.546 ±0.097 | +0.685 ±0.070 | +0.540 ±0.102 | +0.737 ±0.063 |
| Length maxilla | +0.460 ±0.102 | +0.990 ±0.0024 | +0.693 ±0.073 | +0.939 ±0.106 |
| Internasal | −0.441 ±0.105 | −0.450 ±0.102 | +0.335 ±0.125 | +0.204 ±0.127 |
| Interorbital | +0.228 ±0.123 | +0.552 ±0.087 | +0.546 ±0.099 | +0.290 ±0.121 |
| Biparietal | +0.360 ±0.113 | +0.579 ±0.083 | +0.597 ±0.091 | +0.554 ±0.092 |
| Bimastoid | +0.341 ±0.117 | +0.032 ±0.127 | +0.506 ±0.105 | +0.512 ±0.098 |
| Foramen magnum, length | +0.196 ±0.125 | +0.450 ±0.100 | +0.301 ±0.131 | +0.257 ±0.129 |
| Foramen magnum, width | +0.143 ±0.128 | +0.342 ±0.111 | +0.146 ±0.141 | +0.099 ±0.136 |
| Length mandible | +0.492 ±0.098 | +0.980 ±0.0046 | +0.697 ±0.072 | +0.944 ±0.014 |
| Humerus | +0.340 ±0.115 | +0.564 ±0.085 | +0.588 ±0.094 | +0.744 ±0.062 |
| Radius | +0.363 ±0.113 | +0.476 ±0.097 | +0.598 ±0.090 | +0.759 ±0.056 |
| Ulna | +0.349 ±0.114 | +0.569 ±0.085 | +0.568 ±0.095 | +0.760 ±0.056 |
| Femur | +0.326 ±0.116 | +0.518 ±0.092 | +0.622 ±0.086 | +0.690 ±0.069 |
| Tibiofibula | +0.262 ±0.121 | +0.393 ±0.106 | +0.403 ±0.120 | +0.490 ±0.105 |
| Tarsometatarsus | +0.465 ±0.102 | +0.816 ±0.042 | +0.483 ±0.110 | +0.687 ±0.073 |
| Coracoid length | +0.435 ±0.105 | +0.387 ±0.106 | +0.539 ±0.100 | +0.685 ±0.070 |
| Sternal length | +0.573 ±0.089 | +0.643 ±0.075 | +0.517 ±0.104 | +0.577 ±0.088 |
| Sternal height | +0.316 ±0.119 | +0.638 ±0.076 | +0.524 ±0.102 | +0.467 ±0.103 |
| Biacetabular | +0.302 ±0.118 | +0.641 ±0.074 | +0.532 ±0.103 | +0.576 ±0.092 |

TABLE 3

*Asymmetry in weight and length of the paired bones*

| | Males. | | | | Females. | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of cases. | Right greater (%). | Left greater (%). | Same (%). | Number of cases. | Right greater (%). | Left greater (%). | Same (%). |
| **Weights.** | | | | | | | | |
| Humerus | 25 | 48.00 | 52.00 | 0.00 | 21 | 47.62 | 52.38 | 0.00 |
| Radius | 28 | 57.14 | 42.86 | 0.00 | 23 | 73.91 | 26.09 | 0.00 |
| Ulna | 25 | 40.00 | 60.00 | 0.00 | 23 | 56.52 | 43.48 | 0.00 |
| Femur | 27 | 55.56 | 44.44 | 0.00 | 23 | 26.09 | 69.56 | 4.35 |
| Tibiofibula | 26 | 50.00 | 50.00 | 0.00 | 20 | 50.00 | 50.00 | 0.00 |
| Tarsometatarsus | 28 | 53.57 | 42.86 | 3.57 | 24 | 66.67 | 33.33 | 0.00 |
| **Linear dimensions.** | | | | | | | | |
| Humerus | 26 | 34.62 | 50.00 | 15.38 | 21 | 19.05 | 71.43 | 9.52 |
| Radius | 29 | 58.62 | 24.14 | 17.24 | 23 | 69.56 | 26.09 | 4.35 |
| Ulna | 26 | 65.38 | 26.93 | 7.69 | 23 | 56.52 | 26.09 | 17.39 |
| Femur | 28 | 50.00 | 25.00 | 25.00 | 23 | 30.43 | 47.83 | 21.74 |
| Tibiofibula | 27 | 92.59 | 0.00 | 7.41 | 20 | 75.00 | 20.00 | 5.00 |
| Tarsometatarsus | 30 | 63.33 | 13.33 | 23.33 | 24 | 66.67 | 29.17 | 4.16 |
| Coracoid | 28 | 32.14 | 50.00 | 17.86 | 24 | 29.17 | 50.00 | 20.83 |

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XXVII] NOVEMBER 1, 1941 [NO. 2

# Apparatus for Potential Difference Measurements on Single-celled Organisms

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ABSTRACT: This article describes an arrangement of apparatus which has been employed in the measurement of electrical potential differences in a single-celled organism. Combined in this arrangement are an inverted microscope, microelectrodes, a micromanipulator, and a vacuum-tube voltmeter. Special provision is made for simultaneous observation of (1) the organism, and the microelectrodes placed in relationship to same, and (2) the voltmeter indications.

FOR the measurement of potential differences in the protozoön Chaos chaos (Schaeffer, 1936), the original arrangement of apparatus which is herein described has been employed. Arrangements employed in similar studies have been described by Ettisch and Peterfi (1925), Buchthal and Peterfi (1936-'37), Kamada (1934), and others.

The arrangement involves a combination of the micrurgical equipment needful for the placement of microelectrodes in relationship to the cell, together with the appropriate electrical equipment needful for detecting and measuring the potential differences which obtain. Provision is made for the simultaneous observation of the microelectrodes in the microscopic field, and of the voltmeter indications corresponding to manipulation of the microelectrodes in relationship to the organism. (This provision is important for the investigator who works alone.)

The component apparatus of the arrangement are: (1) an inverted microscope, (2) two microelectrodes, (3) a micromanipulator, and (4) a vacuum-tube voltmeter. These components will be indicated at short length, and then the assembly of all to form an experimental unit will be described.

* Work done during the course of graduate study in the Department of Zoölogy, University of Kansas, under the direction of Dr. H. H. Lane.

## COMPONENTS

### 1. INVERTED MICROSCOPE

Since "hanging drop" preparations were found to be impractical,[1] use of same was obviated by recourse to an inverted microscope (Wolfson, 1942).[2] The advantages accruing from employment of this type of instrument are discussed by Chambers and Kopac (1937, p. 71).

### 2. MICROELECTRODE[3]

Two microelectrodes are needed for establishment of electrical contact with the experimental organism. The device employed combines the features of a reversible electrode with those of a micropipette, since the function of the last-named device was essential for the problem in hand. The electrode function was achieved through the agency of a column of liquid electrolyte[4] which is in contact with a chloridized[5] silver wire; it is then a silver-silver chloride electrode. The pipette function was achieved by action of a screw against a rubber diaphragm which is in contact with the column of electrolyte.[6] Sulfur is employed throughout for insulation, and the device is enclosed in a cylindrical shield. The microelectrode tips were drawn after the manner suggested by Chambers and Kopac (1937, p. 78). The essentials of the device are made apparent by figure 1.

### 3. MICROMANIPULATOR

Presumably, any modern micromanipulator[7] could be adapted to fit into the arrangement herein described. A Taylor instrument[8] was employed. The only essential modification deemed desirable was the substitution of a wooden base for the original cast-iron base; for a number of holes had to be drilled through the micromanipulator base and it seemed desirable to avoid such damage to the original base.

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1. The amoeba is likely to fail to adhere to the glass when the cover-slip is inverted; or, assuming that it does adhere, the first touch of the micro-instrument is likely to loosen its attachment. In either case, it falls to the air-water interface, and in such situation is very difficult to contact with a micro-instrument (see Chambers and Kopac, 1937, p. 72).

2. Thanks are due Mr. Fred Johnson, mechanician in the Department of Physiology, University of Kansas, for construction of the instrument.

3. See Blinks (1930) on the preferability of the term "micro-saltbridge."

4. 0.001% NaCl.

5. See Brown (1934) for preparation.

6. See Taylor (1923-'25) for description of a micropipette operating on the same principle.

7. See Chambers and Kopac (1937, p. 69) for references to all micromanipulators described prior to 1937.

8. See Taylor (1923-'25) for description.

### 4. VOLTMETER

The essential qualifications of a voltmeter which shall be appropriate for potential difference measurements on biological materials have been stated by Burr, Lane, and Nims (1936). The instrument employed in the present arrangement[9] is not possessed of the sensitivity and stability qualifications of the Burr, Lane, and Nims (1936) micro-voltmeter; however, both of these characteristics were found to be entirely adequate for measurements of the type achieved with same.[10] The network is described in figure 2, which, together with the accompanying legend, makes apparent the essentials of operating procedure.

## ASSEMBLY

The component parts of the arrangement, indicated in the preceding section, are assembled to form an experimental unit. This assembly will now be described at short length.

1. The inverted microscope is fixed in proper position midway between the control units of the micromanipulator.

2. The microelectrodes are mounted on their respective micromanipulator control units, each through the agency of the large screw which projects from its lower surface (see Fig. 1). The readily-detachable mounting thus achieved is extremely convenient, since frequent removal of the microelectrodes is demanded for various operations.

3. The leads from the microelectrodes to the voltmeter are cylindrical brass tubes, 3/8 inch in diameter and 12 inches long. A copper wire extends through the length of each tube, and is supported therein in sulfur. The brass tube is grounded, and acts as a shield.[11] Junction of the copper conducting wire from the microelectrode with the conducting wire in the brass shield is effected by soldering. This junction is housed in a metal chamber which is a continuation of the voltmeter lead, and is thus shielded.

4. The galvanometer (see Figs. 2, 3) is supported at a height below the level of the table on which the micromanipulator, microscope, and voltmeter rest. The galvanometer scale is fixed to the underside of this table, and is illuminated by a Lumiline bulb. The image of the galvanometer scale which is reflected from the galvanometer mirror is directed, by means of a right-angle prism, into a

9. Designed and constructed by Mr. Bradshaw Burnham, formerly a student in the Department of Physics, University of Kansas.

10. Greater than 10 millivolts, less than 100 millivolts.

11. Flexible braided cable (commercial) was found to be entirely inadequate, because of electrical leakage.

galvanometer telescope mounted to the right of the microscope; it can thus be viewed with the right eye at the same time that the microscope field is viewed with the left eye. The entire assembly is diagrammed in figure 3.[12]

## SUMMARY

An arrangement of micrurgical and electrical equipment appropriate to the measurement of potential differences in single cells is herein described.

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12. The following items are not shown in figure 3: (1) Leads from microelectrodes to voltmeter; (2) microelectrodes; (3) "stage" of the inverted microscope; (4) batteries, potentiometer, and other voltmeter accessories.

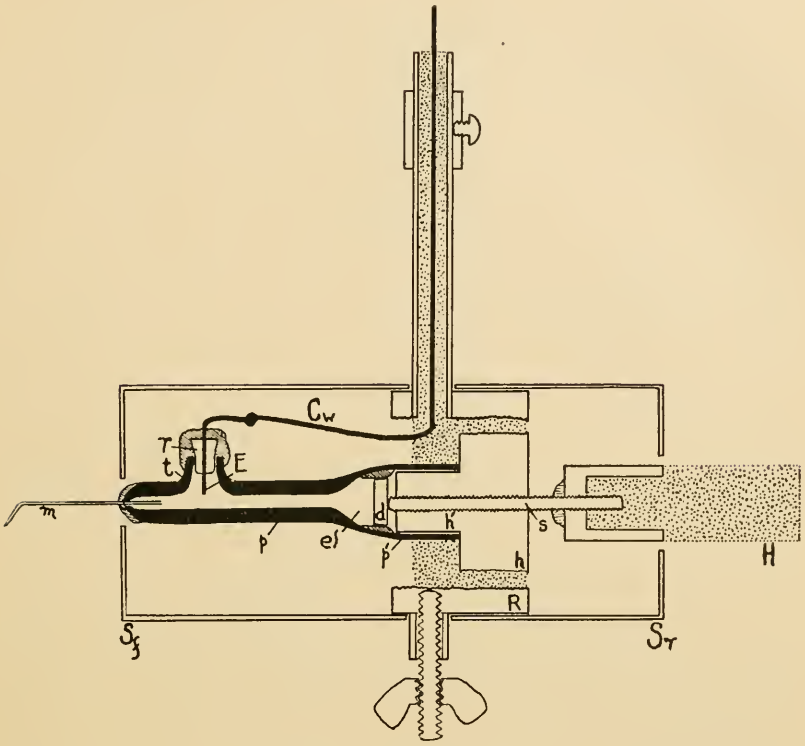


FIG. 1. Microelectrode.

$S_f$—Shield, front section
$S_r$—Shield, rear section

p—Pipette body (Pyrex)
p′—Pipette shank

h—Brass head
h′—Neck on brass head

H—Sulfur handle
E—Chloridized Ag wire
R—Metal ring
$C_w$—Conducting wire
m—Microelectrode tip
r—Rubber stopper
d—Diaphragm (rubber)
s—Screw (3/32)
t—Side-tube
el—Electrolyte (0.001% NaCl)

Stippling—Sulfur (insulation and support).
Diagonal lines—de Khotinsky cement.
Horizontal lines—Solder.

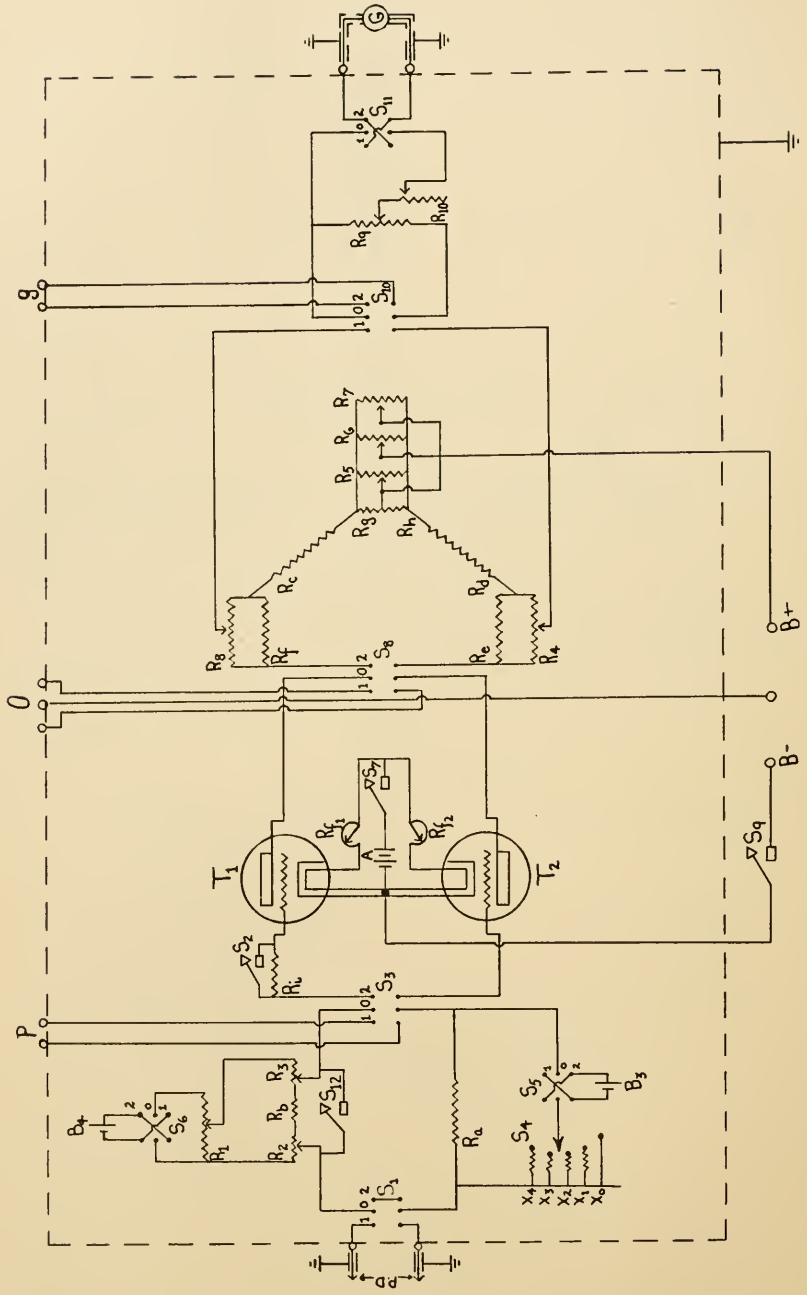
G
S11
R9
R10
S10
g
R7
R6
R5
R3
R4
Rc
Rd
R8
Rf
Re
R4
S8
B+
0
S7
Rf1
Rf2
A
T1
T2
B-
S9
S2
R2
S3
P
R3
Rb
S12
R1
S6
B4
Ra
S4
S5
B3
X4
X3
X2
X1
X0
S1
d

FIG. 2. Voltmeter

*Fixed resistors*

$R_a$ ..... 10 ohms
$R_b$ ..... $10^5$ ohms
$R_c$ ..... $10^4$ ohms
$R_d$ ..... $10^4$ ohms
$R_e$ ..... $10^3$ ohms
$R_f$ ..... $10^3$ ohms
$R_g$ ..... $10^2$ ohms
$R_h$ ..... $10^2$ ohms
$R_i$ ..... $10^7$ ohms
$X_1$ ..... $1 \times 10^3$ ohms
$X_2$ ..... $3 \times 10^3$ ohms
$X_3$ ..... $1 \times 10^4$ ohms
$X_4$ ..... $1 \times 10^6$ ohms

*Variable resistors*

$R_1$ ..... $2 \times 10^4$ ohms
$R_2$ ..... $1 \times 10^4$ ohms
$R_3$ ..... $1 \times 10^3$ ohms
$R_4$ ..... $5 \times 10^3$ ohms
$R_5$ ..... $1 \times 10^3$ ohms
$R_6$ ..... $1 \times 10^4$ ohms
$R_7$ ..... $1 \times 10^5$ ohms
$R_8$ ..... $5 \times 10^3$ ohms
$R_9$ ..... $1 \times 10^4$ ohms
$R_{10}$ ..... $2 \times 10^4$ ohms
$R_{f_1}$, $R_{f_2}$

*Miscellaneous*

P.D. ..... Input P.D.
G ..... Galvanometer
$T_1$, $T_2$ ... Type 89 valve
A .... 6 volt battery (A)
B ... 45 volt battery (B)
$B_3$, $B_4$ ... 1.5 volt battery
$S_2, S_7, S_9, S_{12}$ .... SPST switch
$S_1, S_3, S_8, S_{10}$ ... DPDT switch
$S_5, S_6, S_{11}$, DPDT switch (reversing)
$S_4$ ..... Selector switch
P ... Potentiometer leads
O ..... Oscillograph leads
g ... Galvanometer leads, direct

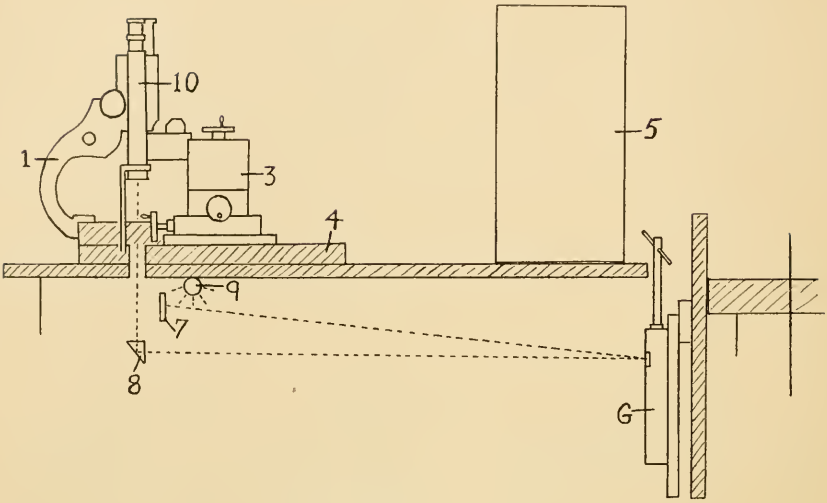


FIG. 3. Assembly (Side view)

1—Inverted microscope
3—Micromanipulator control unit
4—Micromanipulator base
5—Voltmeter
7—Galvanometer scale
8—Prism
9—Lumiline bulb (60 watt; 18-inch)
10—Galvanometer telescope
G—Galvanometer (Leeds & Northup, Type P. Sensitivity: 0.0085 microamperes per millimeter)

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XXVII] NOVEMBER 1, 1941 [No. 3

# The Effects of Drugs Administered Daily in Therapeutic Doses Throughout the Life Cycle of Albino Rats

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## I. ON GENERAL WELFARE, BEHAVIOR AND DEATH RATE

ABSTRACT: Thirteen commonly used drugs have been administered orally to albino rats during what has been the life cycle for the majority of the animals, the dosage being based on the average daily dose for a 70 kg. human.

Caffeine caused a marked increase in activity in females, and toxic effects were apparent in males after 100 weeks.

Phenolphthalein-fed rats showed evidences of toxicity as early as the tenth week by sluggishness, loss of appetite, altered appearance and hypersensitivity to touch stimuli. No laxative effect was observed at any time.

Of six antipyretic- analgesic drugs, aminopyrine alone failed to produce some evidence of toxicity either in the living animal or through an increase in the death rate. Aspirin caused noisy breathing and a soft, light-colored stool. Antipyrine caused no observable effects in the living animal, but increased the death rate rather markedly. Acetanilid, phenacetin, and cincophen produced marked toxic effects after seventy weeks of feeding. The percent of deaths due to pneumonia was increased in the antipyrine and phenacetin groups, but not in the aspirin, cincophen, aminopyrine and acetanilid groups.

Of five barbiturates, only sodium phenobarbital had a significant effect on appetite, reducing it in both sexes. Sodium barbital and sodium amytal caused a marked decrease in activity. Allonal and sodium alurate had no observable effect on the living animal.

All barbiturates caused an increase in the death rate, sodium barbital being most effective and allonal least. The percent of total deaths due to pneumonia was increased in all groups on barbiturates, 100 percent of all deaths in the sodium barbital group being due thereto. Forty-three percent of all rats in the barbiturate groups died with pneumonia as compared to 21 percent in the antipyretic-analgesic drug groups and 11 percent in all controls in the colony.

Macroscopic post-mortem examinations performed on all surviving animals revealed no abnormalities that would differentiate the test animals from the controls.

The authors list the drugs, in order of increasing toxicity, as follows—

Antipyretic-analgesics:

aminopyrine, acetanilid, aspirin, cincophen, phenacetin, antipyrine.

Barbiturates:

Allonal, amytal, alurate, phenobarbital, barbital.

Seven tables are included in the paper.

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THE drug feedings carried out during this two and one-half year experiment were organized for the purpose of emphasizing the factor of time rather than the amount of drug in determining the possible effects of some commonly used drugs on the normal animal. The usual procedure is to give large doses singly or over a short period of time in an attempt to determine the effect or effects on the animal of drugs being investigated, conclusions as to the pharmacological action of the drug being drawn from the results obtained from such medication.

In the investigations to be presented in this and in other papers to follow, dosages comparable to human usage have been administered orally to normal animals which have been kept, as far as possible, in a constant, normal environment with respect to food, housing, temperature, ventilation and general care. The test and control animals have been under almost constant observation throughout what has constituted the life cycle for the majority of the animals. An exhaustive study of the literature has revealed no precedent for this type of investigation, although Slonaker (*1*) has studied the activity of the normal, untreated rat, as well as its rate of growth and life duration, from birth until death from old age.

## CHOICE OF ANIMALS

Only the Wistar strain of albino rat was used for these drug feeding experiments. Six pairs of breeders were obtained from the Wistar Institute and were mated in our own laboratory, twenty-one litters being obtained from the original breeding stock. The largest litter was seventeen young, the smallest, six. There were seven litters of fourteen and six litters of twelve young. One female raised thirty young from two successive litters. The average litter yield was eleven and five-tenths young as compared to the Wistar Institute yield of seven young or less (*2*).

Rats were chosen as test animals for a number of reasons, the most important of which is the fact that the diet of rats resembles very closely that of man, more so than does that of any other experimental animal. Rats thrive on a diet that is normal for human consumption (*2*).

An additional factor favoring the rat as the animal of choice for this type of investigation is well explained in the following paragraphs taken from Greenman and Duhring (*2*):

"A rat of three years is equivalent in age to a man of ninety years. Both are at the close of the life span. The rate of growth in the rat is thus thirty times as rapid as in man. Development in the two forms is in the same stage when equal fractions of their life spans are compared.

"Thus it is possible to verify or apply directly to man experimental data obtained on the albino rat. No other form is at present sufficiently well known to be utilized in this manner."

Similar statements are found elsewhere in the literature. (*3*) (*4*).

## HOUSING AND FEEDING OF ANIMALS

The animals were housed in colony cages with twelve compartments in each, four on a level and three levels high. The compartments measure thirty inches deep, sixteen inches wide and fourteen inches high. They are covered except at the back, and including the bottom, with one-half inch mesh hardware cloth. The back of each compartment is fitted with a nesting box built of wood, ten inches deep by sixteen inches wide and ten inches high. The bottom is constructed of one-fourth inch mesh hardware cloth. The nesting boxes are readily detached from the cage, thus making it possible to remove an entire group of rats from a given compartment without the necessity of catching the animals individually. A hinged door closes the back of the nesting box. This arrangement, together with a hinged door in front, makes the entire compartment easily accessible. The animals spent much of the day in the nesting boxes which are thought to have added considerably to their contentment and well-being. Removable galvanized iron pans placed beneath the wire floor of each compartment and nesting box serve to catch animal and food refuse.

Each compartment is equipped with an exercising turntable ten inches in diameter, built on a bicycle hub. These exercisers were in constant use during the night and served to keep the animals in a healthy physical condition. It is interesting to note, however, that Slonaker (*1*) found that unexercised control rats lived longer than exercised rats, but that the exercised animals were more alert and brighter in appearance than the controls.

The laboratory housing the colony has a high ceiling and is well lighted through east and north windows. The animals were, however, never exposed to direct sunlight. The room temperature may be held within two degrees of 25°C. by a no-draft ventilating system

through the use of an automatic shutter installed in a window. This system allows for maximum ventilation, considering the amount of heat furnished to the laboratory. No attempt was made to control the room temperature during periods when the outside temperature was above 25°C. However, the laboratory was well ventilated during such periods by an 18-inch exhaust fan.

All animals in the colony were fed a cooked ration which was prepared and seasoned as recommended by Greenman and Duhring (*2*). The food was cooked in a large enameled dishpan on a steam kettle. Food was cooked every other day during cold weather and daily during warm or hot weather. The animals were not fed the same mixture of cooked food for more than two days in succession since experience has shown (*2*) that a variety of food elements and combinations is necessary if a colony is to thrive as it should.

The following vegetables and grains made up the menu, at least two of each being used in each cooked mixture: canned peas, tomatoes, beans; fresh string beans, carrots, cabbage, cauliflower, onions, beets, spinach; cracked corn, whole wheat, wheat meal, whole oats, rolled oats. Canned salmon, hamburger and meat stock were alternated in the cooked mixtures.

The cooked food was fed to groups in one-half pound glass ointment jars with a two-inch round hole cut in the cover. The jars were clamped into six inch pie tins to avoid upsetting. The pans also caught much of the food dragged out of the jars during feeding, thus eliminating some of the loss.

The cooked ration was supplemented with Purina Fox Chow bricquets which were kept in the cages at all times and which served as extra food supply if the quantity of cooked food proved insufficient. The outer leaves of head lettuce obtained from the local cafeteria were fed to the animals daily. Milk containing one minim of cod-liver oil per rat was fed twice daily. Butter and raw egg were fed with the milk twice weekly, a quarter of a pound of butter and four eggs being stirred with an electric mixer into the warmed milk for two hundred animals. Once each week the animals were fed what is commonly called dog bone, waste obtained from local meat markets, cooked on the steam kettle. Cuttlebone was also supplied for the purpose of maintaining a healthy tooth condition. Greenman and Duhring (*2*) describe a faulty dentition occasionally occurring in rats, resulting in an excessive and rapid growth of incisor teeth and requiring removal of a part of the tooth with bone forceps. No abnormalities of this sort were noted in our colony of two hundred full-grown animals.

Each compartment was fitted with the usual type of inverted water bottle, 240 c. c. oil specimen bottles serving this purpose satisfactorily.

## FORMATION OF TEST AND CONTROL GROUPS

Only the largest of the twenty-one litters were used for the drug feedings. No litters were used which did not contain at least six males or six females. Several litters contained twelve males, while nine was the largest number of females in any litter. The males or females in a given litter were taken from the mother when twenty-five days old and were divided, respectively, into from three to five groups on a basis of weight. Enough litters were split in this manner to produce at least three groups, one group to be used as controls and the others for drug feedings. Each group contained rats from at least three litters, age variations between all split litters being not more than ten days. This method of splitting litters reduced greatly the number of control groups required. Table 1 lists the groups formed in this manner.

## DRUG ADMINISTRATION—DOSAGE AND METHOD

Drug dosage for rats was figured on a basis of the official or recommended average dose for an adult human. Drug feedings were started when the animals had reached an age of ten weeks. From this period to 200 days of age the test groups were given doses equivalent to the average human dose per kilogram, figuring on a basis of group weight compared to a 70 kg. adult. The original dose was doubled at 200 days of age and trebled at 300 days except for sodium barbital and cincophen. The official dose for these two drugs was 0.5 gm. when these feedings were started. For this reason the twice daily schedule was continued from 200 days of age to the end of the experiment. The schedule of dosage for all groups is given in table 1.

Drugs were fed to test groups in milk. The dose for a given drug was calculated on a basis of group weight, the required amount of drug being thoroughly mixed with milk sugar in a mechanical mixer and by sieving and filled into number O gelatin capsules. Each capsule was prepared to contain the daily dose of the group up to the two-hundredth day. Thereafter the daily dosage was given in divided doses night and morning. A sufficient number of such capsules were filled to last for a two-week period, at the end of which new calculations were made on the weight of the group at that time, a new two-week supply being filled on that basis.

TABLE 1

*Drugs and Drug Dosage per Kilogram of Rat*

| DRUG. | Average human dose. | From 10 weeks to 200 days. | From 200 to 300 days. | From 300 days to end of period. |
|---|---|---|---|---|
| Caffe'ne | 0.20 Gm. | 3.0 mg. | 6.0 mg. | 9.0 mg. |
| Aspirin | 0.30 Gm. | 4.3 mg. | 8.6 mg. | 12.9 mg. |
| Acetanilid | 0.20 Gm. | 3.0 mg. | 6.0 mg. | 9.0 mg. |
| Phenacetin | 0.30 Gm. | 4.3 mg. | 8.6 mg. | 12.9 mg. |
| Cincophen | 0.50 Gm. | 7.1 mg. | 14.2 mg. | 14.2 mg. |
| Antipyrine | 0.30 Gm. | 4.3 mg. | 8.6 mg. | 12.9 mg. |
| Aminopyrine | 0.30 Gm. | 4.3 mg. | 8.6 mg. | 12.9 mg. |
| Phenolphthalein | 0.06 Gm. | 1.0 mg. | 2.0 mg. | 3.0 mg. |
| Sod. Barbital | 0.50 Gm. | 7.1 mg. | 14.2 mg. | 14.2 mg. |
| Sod. Phenobarb | 0.03 Gm. | 0.9 mg. | 1.8 mg. | 2.7 mg. |
| Sod. Amytal | 0.15 Gm. | 2.0 mg. | 4.0 mg. | 6.0 mg. |
| Sod. Alurate | 0.15 Gm. | 2.0 mg. | 4.0 mg. | 6.0 mg. |
| Allonal — Barbiturate | 0.12 Gm. | 1.7 mg. | 3.4 mg. | 5.1 mg. |
| Allonal — Aminopyrine | 0.20 Gm. | 3.0 mg. | 6.0 mg. | 9.0 mg. |

"All" group received all drugs and doses underlined.

Test groups were fed the drug regularly at eight o'clock each morning during the period of once-daily dosage and at eight o'clock a. m. and at five o'clock p. m. after the daily dose was divided. A capsule containing the group dose was emptied into a narrow cylinder containing 2 c. c. of milk per rat, the contents being stirred vigorously with a hand model malted milk mixer. The drug thus prepared was fed to the group in shallow petri dishes. Control groups were fed in the same manner, the capsules containing, however, only milk sugar.

This method of drug feeding has been found to be entirely satisfactory. In no instance have the animals refused the milk containing the drug. All of the animals in a group were at the dish when the milk was poured and remained there until the last drop was consumed. Training and care are undoubtedly important factors involved in this method of drug administration. The feedings were started at an age when the animals were always hungry, apparently regardless of the amount of food in the cage. They gradually became aware of feeding time because of the noise made by the mixer and would crowd to the front of the cage and remain there until the milk was placed in their dishes. The animals were com-

pletely tamed through daily handling and evidenced no signs of fear toward regular attendants.

## DRUGS INVESTIGATED

Thirteen commonly used drugs were administered to albino rats during this two and one-half year feeding period. Sodium phenobarbital (Merck), aspirin (Merck), and caffeine (Merck) were fed to both male and female groups. Sodium barbital (Merck), sodium amytal (Lilly), phenacetin (Merck), cincophen (Mallinckrodt), acetanilid (Mallinckrodt), and phenolphthalein (Mallinckrodt) were fed to males only. Sodium alurate (Roche), allonal (Roche), aminopyrine (Merck), and antipyrine (Mallinckrodt) were fed to females only. All of the drugs with the exception of sodium amytal, sodium alurate and allonal are official. Only allonal of the thirteen drugs has not been accepted into New and Nonofficial Remedies (*5*).

Especial attention is called to the fact that one group of eight males called the "All" group received nine of the thirteen drugs in exactly the same dosage given to groups receiving the drugs individually. The drugs and doses received by this group are underlined in table 1. These animals received sodium barbital as a representative of the barbiturate drugs, and eight nonbarbiturate drugs, as shown in the table.

## EFFECTS ON GENERAL WELFARE AND BEHAVIOR

For the purpose of discussion it seems desirable to divide the thirteen drugs as follows—

1. Nonbarbiturate nonantipyretic group, which includes caffeine and phenolphthalein.
2. Antipyretic drugs, including aspirin, acetanilid, phenacetin, cincophen, antipyrine, and aminopyrine.
3. Barbituric acid derivatives—sodium barbital, sodium phenobarbital, sodium amytal, sodium alurate and allonal. Allonal is a mixture of allylisopropyl barbituric acid and aminopyrine.
4. The "All" group.

## CAFFEINE

Caffeine was given orally to both male and female rats, from the tenth to the one hundred fifth week for males and to the one hundred twentieth week for females. Pertinent dosage data, size of groups, etc., is presented in tables 1 and 2. The maximum daily dosage of 9.0 mg. per kg. was administered during the adult portion of the life cycle. The average single dose for an adult human is 3.0 mg. per kg.

TABLE 2

*Summary of Drugs, Dosage and Feeding Periods*

| Drug | Sex. | Rats in group. | Feeding period in weeks. | Equivalent period for human (30–1). | Number of doses per rat. | Equivalent number of human doses. | Max. dose used in mg. per Kg. | Literature M. L. D. for rats mg. per Kg. | Max. dose percent of Literature M. L. D. |
|---|---|---|---|---|---|---|---|---|---|
| Caffeine | Males | 7 | 95 | 2850 | 1425 | 42750 | 9.0 | 200+ | 4.5 |
| Caffeine controls | Males | 7 | 100 | 3000 | | | | | |
| Aspirin | Males | 9 | 100 | 3000 | 1530 | 45900 | 12.9 | 1240+ | 1.1 |
| Phenobarb (Na) | Males | 9 | 100 | 3000 | 1530 | 45900 | 2.7 | 180 | 1.5 |
| Aspirin Phenobarb. controls | Males | 9 | 100 | 3000 | | | | | |
| Barbital (Na) | Males | 13 | 90 | 2700 | 990 | 29700 | 14.2 | 315 | 4.5 |
| Amytal (Na) | Males | 11 | 90 | 2700 | 1320 | 39600 | 6.0 | 125 | 4.8 |
| Barbital Amytal controls | Males | 10 | 90 | 2700 | | | | | |
| Phenolphthalein | Males | 4 | 86 | 2580 | 1236 | 37080 | 3.0 | 1250+ | 0.24 |
| Phenacetin | Males | 6 | 86 | 2580 | 1236 | 37080 | 12.9 | 1250+ | 1.03 |
| Cincophen | Males | 6 | 86 | 2580 | 990 | 29700 | 14.2 | 1250+ | 1.14 |
| Acetan | Males | 6 | 86 | 2580 | 1236 | 37080 | 9.0 | 2400+ | 0.38 |
| "All" group | Males | 8 | 86 | 2580 | 10520 | 315,600 | 129.8 | | |
| controls | Males | 8 | 86 | 2580 | | | | | |
| Caffeine | Females | 7 | 109 | 3270 | 1719 | 51570 | 9.0 | 200+ | 4.5 |
| Caffeine controls | Females | 5 | 109 | 3270 | | | | | |
| Aminopyrine | Females | 9 | 90 | 2700 | 1320 | 39600 | 12.9 | 1150+ | 1.1 |
| Antipyrine | Females | 9 | 90 | 2700 | 1320 | 39600 | 12.9 | 1215+ | 1.1 |
| Aminopyrine Antipyrine controls | Females | 9 | 90 | 2700 | | | | | |
| Phenobarb. (Na) | Females | 8 | 100 | 3000 | 1530 | 45900 | 2.7 | 180 | 1.5 |
| Aspirin | Females | 8 | 100 | 3000 | 1530 | 45900 | 12.9 | 1240+ | 1.1 |
| Aspirin controls | Females | 8 | 100 | 3000 | | | | | |
| Alurate (Na) | Females | 10 | 90 | 2700 | 1320 | 39600 | 6.0 | 155 | 4.0 |
| Allonal | Females | 9 | 90 | 2700 | 1320 | 39600 | 14.1 | ? | ? |
| Alurate Allonal controls | Females | 9 | 90 | 2700 | | | | | |

Sollmann and Pilcher (*6*) have found that the fatal dose of caffeine when injected into the femoral vein varies markedly between 57 mg. and 800 mg. per kg. of body weight. They have accepted 175 mg. per kg. as the mean fatal dose for dogs, cats and rabbits.

Pilcher (*7*) has administered caffeine by stomach tube to cats in 5, 15, 30 and 60 mg. per kg. doses and has found that doses between 5 and 30 mg. per kg. produced wakefulness in the animals. They were also thought to be a little more irritable.

Schulte *et al.* (*8*) have found that 10 mg. per kg. of caffeine sodium benzoate, when administered subcutaneously to rats, produced the threshold increase in activity. These authors also found that 20 mg. per kg. of caffeine sodium benzoate produced larger increases in activity and that 40 mg. per kg. caused very marked stimulation. The latter dose killed one of the ten animals.

Eichler and Mugge (*9*) have subjected white rats to chronic poisoning with caffeine by giving daily doses of 100 mg. per kg. of body weight. The animals have been observed through four generations of interbreeding and the authors state that no ill effects, other than a transient fall in weight occurring just after medication was begun, have been noted.

During this investigation the males on caffeine have shown no significant variations from their litter-mate controls during the greater part of the feeding period, i, e., from the tenth to the one hundredth week. No differences in general behavior attributable to caffeine medication were noticed, although the animals were under almost constant observation. They possessed good appetites, but there was no evidence of an increased desire for food. There was no recognizable increase in activity during the day, the normal rest period for albino rats, as compared to their controls.

At about the one hundredth week, however, decreases in both appetite and activity were observed, the animals falling off rapidly in appearance and weight. The three animals remaining in the group at the end of the one hundred fifth week were actually killed to keep them from dying, in order that the internal organs and blood could be examined. During this same part of the feeding period the controls were in good health, gaining 30 gm. per rat, while the males on caffeine were losing the same amount.

The caffeine females, in contrast to the caffeine males, showed an increased desire for food early in the experiment. This was evidenced by the fact that they crowded around the feeding dishes when the noises normally made at feeding time were duplicated at

off-feeding periods. They would accept milk at almost any time of day, while it was unusual if their controls could be aroused from their nesting box by similar experiences. There was, however, no evidence of an increase in total food consumption. Attempts were made to determine possible variations in food consumption accurately, but the wasteful tendency of the rat makes such determinations of little value, in the experience of the authors, at least.

The females on caffeine were carried through to the one hundred twentieth week and there was no evidence of delayed toxicity during the last several weeks as there was in the male group.

The females on caffeine were observed to be about the cage much more during the day than were their litter-mate controls. They were also observed to use the turntable exerciser much more during the day than did other groups. This increased activity was noticeable as early as the twentieth week of feeding and became more marked as the experiment progressed. This increased activity in the caffeine females was proved more conclusively by their actions on the maze during maze learning and relearning, total time and travel time being significantly less for the caffeine females than for their controls.

That there is a sex variation to the effects of caffeine has been shown by Horst and Willson (*10*). These investigators have measured the amount of tremor in the index finger of young men and women after drinking coffee. They have found that a cup of strong coffee containing one and one-half to two grains of caffeine produced a certain increase in the amplitude of the tremor in women, but that it took more than twice this amount to produce the same effect in men.

The authors are fully aware that it would be unsafe to draw any conclusions concerning the effect of caffeine on the length of the life span from the meager data presented herein. It is safe to say, however, that the litter mates controlling the males on caffeine were in a much better state of health than were those that had received the drug during the ninety-five week period. Four of the controls were kept for three weeks after the test animals were killed, as has been stated, to keep them from dying, and there were no signs of senility at the end of the period.

## PHENOLPHTHALEIN

Toxic reactions resulting from the use of phenolphthalein as a laxative have been reported frequently in the literature of recent years. Ayers (*11*), Ely (*12*), Newman (*13*), Phillips (*14*), Weiss and Kile (*15*) and others have reported skin eruptions, swollen eyelids and lips and intense itching and burning as the prevailing symptoms.

Statements of minimal lethal dose of phenolphthalein for any animal have not been found in the literature. Wood (*16*) has found that doses equivalent to sixty to one hundred grains for human beings were quite harmless to dogs. Abel and Rowntree (*17*) have administered large doses of the drug (0.415 gm. to 1.0 gm.) orally, subcutaneously and intravenously to a dog over a three-month period without harmful effect.

Phenolphthalein seems to have had a toxic effect on male rats given the drug during this drug feeding experiment. There were four rats in the group originally and only one of the animals survived the eighty-six week feeding period. The maximum daily dose (Table 1) was 3 mg. per kg. body weight, three times the average adult human dose.

Sluggishness and a decreased desire for food were observed in the phenolphthalein group as early as the tenth week of drug feeding, the animals failing to gain weight as rapidly as did their littermate controls.

A peculiar hypersensitivity to touch stimuli was observed in the group as early as the twentieth week of drug feeding. It was first evidenced when the animals became difficult to catch. The normal, tamed rat can be picked up without difficulty if the animal is aware that the hand is approaching. It merely assumes a slightly crouched position and offers little or no resistance. The phenolphthalein animals, however, seemed to object to being touched, and while they would assume the crouched position normally, they would jump at the first touch of the hand. This apparent hypersensitivity became more marked as the experiment progressed, it being almost impossible to catch the one animal that survived the entire feeding period. This peculiarity was observed as a result of other stimuli such as being touched by other animals in the group or by lettuce or other food thrown into the cage. This excessive response to touch stimuli was not observed in any other group in the colony.

That this hypersensitivity was a result of phenolphthalein medication would seem to have been proved by the fact that symptoms were alleviated markedly by a five-week abstinence period which

followed seventy weeks of medication. The drug was returned to the diet at the end of the seventy-fifth week, the symptoms gradually returning but never becoming as marked as they were before the withdrawal period. The experiment was stopped at the end of the ninety-sixth week of age.

There was never any evidence of a laxative effect as a result of phenolphthalein administration. The fecal material was normal in color and consistency throughout the period of feeding. Phenolphthalein, or some substance giving a red color in alkaline solution, was identified in the feces of the phenolphthalein animals when the test was made after five weeks of feeding, while the group was receiving only 1.0 mg. per kg. of drug daily. Positive tests were obtained at irregular intervals thereafter. Similar tests performed on the feces of controls were always negative.

## ANTIPYRETIC DRUGS

Many cases of mild and severe poisoning by *aspirin* have been reported in the literature, although the dose in most cases has been extremely large. Krasso (*18*) states that the toxicity of the drug depends largely upon individual tolerance, that some individuals show toxic symptoms even after 5 grains, while others do not react after doses as high as 26 grains. Urticaria following the use of aspirin has been reported by a number of investigators (*19*), (*20*), (*21*). Dyke (*22*) has listed nausea, tinnitus, deafness and mental wandering as symptoms occurring after a patient had taken 435 grains of aspirin. Recovery was complete, however. Lipetz (*23*) has reported a similar recovery after the ingestion of 600 gr. of the drug by a forty-eight-year-old man who experienced a rushing feeling in the head for a short time, but was able to work as usual in two days. Neale (*24*) has listed four deaths resulting from aspirin overdosage. It was not known how much one case had taken, but the other three had taken 200, 750, and 1,000 grains, respectively. Prickman and Buchstein (*25*) have reported sixty-two cases of hypersensitivity to aspirin and state that it is the most common form of drug allergy.

Robinson *et al.* (*26*) have administered daily doses of aspirin ranging from 22 mg. to 623 mg. per kg. of body weight to white rats varying in age from nine to twenty-nine weeks, the medication extending over a period of twenty-nine weeks. They report no effects on general physical condition, growth curves, appetite, activity, coat condition and appearance of the animals. Four animals received doses in excess of the beginning lethal range for humans, 280 mg. per kg., for seven weeks without observed effect.

Schnedorf *et al.* (*27*) have found, however, that prolonged daily administration of aspirin, 150 mg. per kg. body weight twice daily, resulted in digestive disturbances in dogs.

Lehman (*28*) has studied the respiratory inhibitory and paralytic effects of aspirin in dogs, cats, and rabbits. He states that the drug produces only slight or no direct depressant or paralytic effects on the central or peripheral respiratory mechanisms when administered in reasonable doses. Large doses produce circulatory collapse as a result of cardiac arrest and respiratory failure due to asphyxia. The respiratory paralytic dose for aspirin was stated to be between one and 1.5 gm. per kg. of body weight, the paralysis resulting in from eight to sixteen minutes.

Shimamura and Akira (*29*) have found that large doses of aspirin, when given by stomach tube to rats, caused stomach ulcers and bleeding. Bleeding alone resulted from similar medication in mice. Subcutaneous injection of aspirin produced no changes.

Thompson and Dragstedt (*30*) and Barbour and Porter (*31*) have reported gastritis and ulceration in dogs following large doses of aspirin. Barbour and Dickerson (*32*) have produced gastric ulcers in rats by the administration of 300 mg. oral doses of aspirin. Douthwaite and Lintott (*33*) and Wyllie (*34*) have reported that aspirin is a gastric irritant in humans, causing acute indigestion and hemorrhage, or, if taken repeatedly, chronic gastritis.

Albricht (*35*) has compared the analgesic effects of aspirin, aminopyrine, antipyrine and phenacetin, all of which were used in this experiment. He states that aminopyrine is undoubtedly best with aspirin next in effectiveness, and antipyrine third. Phenacetin, according to Albricht, is least effective.

Brownlee (*36*) has compared the antipyretic activity of acetanilid, aminopyrine, phenacetin, antipyrine and aspirin by oral administration of different doses of the drugs to cats and rats. He states that if phenacetin is taken as 100, aspirin has a potency of 74, antipyrine 100, aminopyrine 134 and acetanilid 170. The toxic dose for rats, in gms. per kg., takes the following order—acetanilid 0.82 gm., aminopyrine 1.15 gm., phenacetin 1.25 gm., aspirin 1.24 gm., antipyrine 1.53 gm. The equivalent therapeutic dose in terms of mgm. per kg. of rat is given by Brownlee as follows—acetanilid 24, aminopyrine 31, phenacetin 40, antipyrine 40 and aspirin 54. These doses are all observed to be considerably larger than the maximum doses used for these drugs during these experiments.

*Acetanilid* has undoubtedly been the subject of more adverse criti-

cism in the clinical literature of the past four decades than any other drug. As early as 1905 the Council on Pharmacy and Chemistry of the American Medical Association included in its reports (*37*) a warning of the possible dangers accompanying the use of mixtures containing acetanilid.

The most frequent source of poisoning has been from its indiscriminate use for headache. Of 614 cases of poisoning reported by physicians to the United States Department of Agriculture (*38*) between the years 1886 and 1910, 325 cases or 53 percent occurred when the drug was taken without a physician's prescription.

Helms (*39*) has stated that his experiments were performed to correct the erroneous impressions concerning the pharmacological and physiological action of acetanilid. He gives 1,500 mg. per kg. as the M. L. D. for guinea pigs and rabbits, and 2,400 mg. per kg. for rats. Mice, according to this author, will survive up to 1,350 mg. per kg. of acetanilid when given hypodermically and will take half that amount daily in their drinking water with no effect other than a delay in growth which is regained when the drug is withdrawn. Mice given 500 mg. per kg. daily for one month tripled their weight. Helms fed rats from 5 to 10 mg. per kg. of acetanilid daily in milk through four generations and found that the animals reproduced and developed normally, cared for the young in a normal manner and showed no deviation in morbidity or mortality from the average of an unmedicated rat population.

Higgins and McGuigan (*40*), Fantus *et al.* (*41*) and Stanton and Agricola (*42*) have also administered enormous doses of acetanilid to mice and rats without apparent effect. Smith and Hambourger (*43*) have reported that acetanilid produces little tolerance and no addiction in monkeys even after sixty-five days of daily administration of 100 to 500 mg. per kg. of body weight. Many authors, however, (*44*), (*45*), (*46*), consider acetanilid to be habit-forming.

*Phenacetin,* according to Brownlee (*36*), is considerably less toxic when given orally to rats than acetanilid. In terms of gms. per kg. body weight he compares them as 1.25 to 0.82. Equivalent therapeutic dose and relative antipyretic potency comparisons are similar.

Solis-Cohen and Githens (*91*) quote Mahnert as having found that as much as 1.0 gm. per kg. of phenacetin may be given by mouth to rabbits and dogs with no disturbances other than sleepiness, nausea and shivering. Death, according to this author, results when a 3.0 gm. per kg. dose is given to rabbits by mouth. Wood and Wood (*91*) have found that a dose of 0.5 gm. per kg. by vein will produce death in dogs.

*Aminopyrine* and *antipyrine*, though closely related chemically, have, according to Brownlee (*36*), rather marked differences in toxicity when compared on rats. In terms of gm. per kg., the toxic dose for aminopyrine is 1.15 gm., and for antipyrine 1.53 gm. The equivalent therapeutic dose in mg. per kg. is given as 31 and 40, respectively, and the relative antipyretic potency 134 and 100.

Bernheim (*47*), in studying the action of aminopyrine and antipyrine upon the oxidation of phospholipid by various tissues, has found that the oxygen uptake of rat tissues is inhibited 20 to 30 percent by M/4500 solutions of aminopyrine, but that six to ten times this amount of antipyrine is without effect.

Gunn (*48*) has given 0.9 gm. per kg. of body weight as the M. L. D. of antipyrine for mice when injected intraperitoneally, while the subcutaneous injection of 1.0 gm. per kg. in guinea pigs produced death in from one to one and one-half hours.

Rose (*49*) has found 150 mg. per kg. to be the M. L. D. for aminopyrine in mice, and 135 mg. per kg. in rats. The drug was injected into the tail vein.

Many cases of *cincophen* poisoning have been reported in the literature during the last fifteen years. Weir and Comfort (*50*), in 1933, reviewed the case histories of 117 cases and stated that sixty-one patients had died, and that many others were seriously ill. Palmer and Woodall (*51*) reviewed the literature on cincophen toxicity in 1936. They stated that 191 cases of jaundice following the use of cincophen had been reported in the preceding decade, eighty-eight, or 46.3 percent of which ended fatally. These authors state that there is no safe method for the administration of cincophen.

Evans and Spence (*52*) stated in 1929 that cincophen had proved of great value in the treatment of gout, and that proper dosage would eliminate toxic results. Davis (*53*), in 1932, reported on 200 cases that had taken cincophen and neocincophen with no fatalities resulting. Thirty of the 200 had slight digestive or circulatory upsets.

There are many reports in the literature concerning the experimental production of peptic ulcers in laboratory animals by the administration of cincophen. Stalker *et al.* (*54*) have produced ulcers in 95.8 percent of their test animals by oral administration of large doses of the drug. Cincophen administered by rectum, parenterally, through intestinal fistulas, or orally, in dogs with fundic pouches, produced peptic ulcers in many instances, and these results were taken as proof that ulceration occurred after the absorption of the drug. Except for the mild, pathologic changes which accompany the

toxemia produced in the first few days, no changes, either gross or microscopic, which could be attributed to cincophen, where seen by these authors in the liver, heart, spleen, lungs, pancreas, kidneys, gallbladder or adrenal glands.

Churchill and Manshardt (*55*) have produced chronic ulcers in the pyloric region of the stomach of dogs by the injection of cincophen dissolved in olive oil directly into the jejunum. One dog received twenty-two 220 mg. per kg. doses during as many days, resulting in a consistently bloody stool. There was no ulceration at the point of injection.

Schwartz and Simonds (*56*) were able to produce gastric ulcers in cats, but not in rabbits and guinea pigs by oral administration of therapeutic doses of cincophen, *i. e.*, 22 mg. per kg. daily. One cat survived this dosage for sixty-two days. None of the rabbits died from the effects of the drug, and one rabbit survived sixty-six doses, each twenty-five times the normal human dose, without apparent injury.

Radwin and Lederer (*57*) have given 0.5 gm. to 1.0 gm. per kg. as the lethal dose of cincophen for white rats. Reichle (*58*) has found that the subcutaneous administration of 1.0 gm. per kg. doses of cincophen killed rats in twenty-four hours. Continued parenteral administration of 0.2 gm. per kg. did not cause death, but there was a period of excitement followed by collapse immediately following the injection.

Of the six antipyretic, analgesic drugs administered to white rats during this investigation, only the groups on aminopyrine and antipyrine have failed to show some evidence of toxicity as judged from general appearance and behavior. These two closely related drugs have produced no effects that would differentiate the test animals from litter-mate controls. Abstinence symptoms were not observed in any of the test animals during four and one-half weeks of withdrawal, from the sixty-ninth to about the seventy-fourth week of drug administration.

Acetanilid and phenacetin, closely related chemically, have produced no observable effects during the first seventy-two weeks of drug feeding. However, at about the seventy-second week, at the age of eighty-two weeks, both acetanilid and phenacetin-fed groups began to show evidences of toxic effects. Appetites decreased rapidly and the animals began to lose weight. They became hunched and dejected in appearance, and paid little attention to care or feeding noises. The progress of symptoms was identical in both test groups.

During this same period the litter mates controlling both the acetanilid and phenacetin groups were normal in every respect.

Drug feeding was stopped at the beginning of the seventy-sixth week, no correction of symptoms being observed during a five-week abstinence interval. Both test groups were losing ground rapidly when the experiment was terminated after eighty-six weeks. The failure of the five-week withdrawal period to alleviate the symptoms produced by the long term administration of the drugs would seem to indicate that the toxic effects were permanent. However, as will be shown in a later paper on growth effects, acetanilid and phenacetin were of benefit to the animal during the first seventy-two weeks of administration.

Aspirin was given to both male and female groups during the investigation. There was no evidence of blood in the feces of either group, and the animals have shown no symptoms that would suggest abdominal disturbances as a result of the medication. Neither males nor females on aspirin evidenced any variations in appetite or activity as compared to litter-mate controls.

A rather marked laxative effect was observed in both males and females on aspirin between the tenth and thirty-fifth weeks of feeding. The fecal material was more moist and much softer than that of the controls. It was also noticeably lighter in color. After the thirty-fifth week the laxative effect was no longer evident, but the color of the fecal material remained lighter throughout the feeding period. A positive salicylate test was obtained from the feces of both males and females on aspirin at the tenth week, and at irregular intervals thereafter. The fecal material was extracted with water, and to the filtered liquid was added a small amount of ferric chloride solution. A violet color was considered positive for salicylates. Feces from the controls gave no such color.

During about this same period, from the tenth to the thirty-fifth weeks of feeding, noisy breathing was noticeable in both males and females on aspirin, being much more marked in the males. Their breathing could be heard without difficulty from any point in the laboratory. Breathing was not labored, and it seemed to cause little, if any, inconvenience. This abnormality was entirely absent after about the thirty-fifth week.

The aspirin males were without the drug for three weeks following the eighty-first week of administration. Withdrawal effects were not observed during this period. During this same three-week period, sodium amytal in therapeutic dosage was added to the aspirin

for the female group for the purpose of determining possible effects of the combination of drugs on the blood picture. No untoward symptoms were observed in the animals as a result of the added amytal.

Cincophen, like acetanilid and phenacetin, produced no observable symptoms during the major portion of the feeding period, about sixty-five weeks. Blood was absent from the stool during the entire feeding period, and the fecal material was normal in color and consistency. At about the sixty-fifth week of feeding, at seventy-five weeks of age, toxic symptoms began to appear. The fur became coarse and rough, and the animals became less active, using the turntable exercisers very little during the last ten or fifteen weeks. Appetites decreased markedly after the seventieth week on cincophen, and the animals lost weight.

Withdrawal symptoms were not observed during a five-week period without the drug following the seventy-sixth week of feeding. There was no improvement in the general condition of the animals. The toxic symptoms were not lessened, and the animals continued to lose weight.

## BARBITURIC ACID DERIVATIVES AND ALLONAL

Reports of pathological disturbances and deaths resulting from the use of barbiturates are numerous in the literature of recent years. Lynch (*59*) reports that deaths in humans have been caused by a single 15-grain dose of barbital and of phenobarbital, but that the average fatal doses are larger. Rylander (*60*) places the smallest lethal dose of barbital at 11 grains, and the average fatal dose at 50 grains. Ravine (*61*) reports a case of barbital poisoning in which the patient had taken daily doses of 3 to 6 grains over a period of four to five years. The symptoms were tremor, weakness, restlessness and mental dullness, all of which disappeared after discontinuing the drug. Birch (*62*) has reported toxic symptoms in a case after one grain of phenobarbital had been given daily for twenty-two days.

Larkum (*63*) has reported a case of probable allonal poisoning, but no exact estimate of the dose other than a minimum of 60 grains could be given. Loveman (*64*) has reported a toxic reaction due to alurate, the barbituric acid derivative of allonal.

There are also many reports on the relative harmlessness of some of the barbiturates. Hoge (*65*) reports on a case, a woman, age 41 years, who had taken three or four 1.5 grain amytal tablets daily

over a period of seven years with little or no harm. Lundy and Dixon (*66*) state that a case had taken a total of 600 gms. of sodium amytal in 0.2 gm. hourly doses over a period of four months with no harmful effects. Bleckwenn (*67*) mentioned a case in which 250 daily doses of 1 to 1.4 gm. of sodium amytal were injected intravenously with no pathological changes being noted and no habit formation suspected. Weiss (*68*), in discussing the whole group of barbiturates, states that if the scientific definition of the term were adhered to, no habit formation could be attributed to them.

A number of minimum lethal doses reported in the literature by investigators for the four barbiturates used in this study are presented in table 3. No statement of M. L. D. for allonal has been found, but since the barbituric acid content of the mixture is alurate, the M. L. D. is considered to be similar.

TABLE 3

*Literature Minimum Lethal Dose*

(In mg. per kg. body weight)

| Literature Reference. | Barbital. | Amytal. | Phenobarb. | Alurate. |
|---|---|---|---|---|
| (69) 1926 rat subcu | 310 | 140 | 140 | 125 |
| (70) 1927 rat subcu | 310 | 100 | ..... | ..... |
| rabbit subcu | 290 | 110 | ..... | ..... |
| cat oral | 230 | 110 | ..... | ..... |
| (71) 1928 cat oral | 230 | 100 | ..... | ..... |
| (72) 1929 dog I. V | (Na) 400 | ..... | ..... | ..... |
| (73) 1931 dog oral | ..... | (Na) 125 | ..... | ..... |
| dog rectal | ..... | (Na) 200 | ..... | ..... |
| dog I. V | ..... | (Na) 70-75 | ..... | ..... |
| (74) 1932 rabbit oral | 275 | 575 | 150 | 160 |
| rat I. P | 300 | 115 | 155 | 100 |
| (75) 1933 rabbit intramusc | ..... | ..... | (Na) 150 | ..... |
| (76) 1936 rat subcu | ..... | ..... | (Na) 215 | ..... |
| (77) 1937 rat I. V | (Na) 300 | ..... | ..... | ..... |
| rat I. P | (Na) 350 | ..... | ..... | ..... |
| rat oral | (Na) 400 | ..... | ..... | ..... |
| (78) mice subcu | ..... | ..... | (Na) 265 | (Na) 237 |

Nielsen *et al.* (*69*) have found that cats and dogs are unsatisfactory for comparative tests on the barbituric acid series, but that rats react readily and with sufficient constancy. In order of increasing toxicity these four barbiturates are listed as follows—barbital, amytal, phenobarbital, alurate. In order of increasing safety margin—phenobarbital, barbital, alurate, amytal.

Eddy (*79*) has found that no tolerance to barbital developed in cats after long continued administration of hypnotic doses, a cumulative effect developing in only one animal. Cumulation of effect did appear, however, during the first few days of the administration of a small dose, but disappeared as the dosage was continued. Gower and Tatum (*72*) have found that dogs develop a tolerance to barbital, such development being proportional to the rate of excretion.

Oettel and Krautwald (*81*) have given barbital and phenobarbital to dogs in daily doses of 100 mg. and 75 mg. per kg., respectively, for a month. Habituation accompanied by increased excretion is reported, but there were no abstinence symptoms on withdrawal. Stanton (*82*) has found that rats show no increase in abstinence irritability to sodium phenobarbital after daily injections of 5 and 15 percent of the M. L. D. over a seven-week period. Rats, therefore, according to Stanton, do not become addicted to the drug, but tend rather to show evidences of some cumulation of depressive effect.

Fitch (*80*) has reported that rabbits developed a high degree of tolerance to amytal, neonal and noctal. Amytal, in doses of 550 mg. per kg., killed four of six previously untreated rabbits, while the same dose killed none of three addicts. Swanson *et al.* (*83*) seem to have eliminated the possibility of habit formation from the prolonged use of amytal by continued oral administration in dogs and intravenous injection in monkeys of large doses of the drug.

Sex variations to the effects of barbiturates have been reported in the literature. Holck and Kanan (*84*) have found that female white rats are more sensitive than males to amytal, nembutal, evipan, pernocton and hebral. White rats, according to these authors, show no sex difference in sensitivity to barbital or phenobarbital. Nicholas and Barron (*85*) state that the female dosage for sodium amytal in white rats is just one-half the male dosage, and that immature rats require the lower dosage. Moir (*86*) has found that very young females are more resistant than corresponding males to pentobarbital, but that mature females are less resistant than mature males.

The possibility of temperature and seasonal variations, as well as variations in diet, on the effects of barbiturates has been considered by various workers. De Beer *et al.* (*87*) report the absence of significant seasonal variations in the toxicity of the sodium salt of ethyl n-hexyl barbituric acid. They state further that no detectable error in the determination of hypnotic potency is introduced into the experiment by making dosage proportional to body weight. They did find, however (*92*), significant differences in the minimal hypnotic and minimal lethal doses in mice on two widely different diets, there being a marked difference in the duration of anesthesia. Nedzel (*88*) has found that many rabbits on an oat diet would undergo a prolonged general narcosis with a given dose of sodium phenobarbital, while only a few were found to do so on a diet of carrots. Complete narcosis was produced more quickly on a mixed

diet than on either carrots or oats alone, but the effect faded comparatively soon.

Raventos (*89*), using male mice, has found a marked difference in the median hypnotic dose and M. L. D. of sodium phenobarbital at 30° C. and at 20° C. The M. H. D. at these temperatures are 105 and 90 mg. per kg., and the M. L. D. 234 mg. and 162 mg., respectively, a thirty percent decrease in the M. L. D. It would therefore seem necessary that the room temperature be rather carefully controlled during such experiments.

Hirschfelder and Rice (*90*) have found that fear and excitement definitely diminish the soporific action of sodium barbital in white rats.

Four barbituric acid derivatives and one mixture of barbiturate and aminopyrine (allonal) were given orally to white rats during this investigation. The dosage schedule for these drugs is given in table 1 and other pertinent data in table 2.

Barbital and amytal (sodium salts) were administered to littermate male groups, both groups being controlled by male rats from the same litters. Allonal and sodium alurate were fed to female groups which were litter mates, controlled by the same group of litter mates. All animals comprising the groups described in this paragraph, both male and female, were from the same litters.

Sodium phenobarbital was fed to both males and females from identical litters, the controls being from the same litters.

Dosage data for the test groups described above may be summarized as follows—

Barbital sodium, daily dosage range from 7.1 to 14.2 mg. per kg. body weight over a period of ninety weeks, the maximum dosage being 4.5 percent of the average literature M. L. D. of 317 mg. per kg.

Amytal sodium, daily dosage range from 2.0 to 6.0 mg. per kg. over a period of ninety weeks, the maximum dosage being 4.8 percent of the average literature M. L. D. of 125 mg. per kg.

Phenobarbital sodium, daily dosage range from 2.0 to 6.0 mg. per kg. over a period of 100 weeks, the maximum dosage being 1.5 percent of the average literature M. L. D. of 180 mg. per kg.

Alurate, daily dosage range from 2.0 to 6.0 mg. per kg. over a period of ninety weeks, the maximum dosage being 4.0 percent of the average literature M. L. D. of 155 mg. per kg.

Allonal, daily dosage range from 1.7 to 5.1 mg. per kg. of alurate and from 3.0 to 9.0 mg. per kg. of aminopyrine over a period of ninety weeks. M. L. D. for allonal not found in the literature.

Almost constant observation of the six groups of rats on barbiturates failed to reveal any marked variations in appearance or

general welfare that would differentiate the animals from their controls. There was no sign of chronic respiratory infection as mentioned by Nicholas and Barron (*85*) after the use of amytal.

Appetites were comparable to controls in all groups with the exception of those on sodium phenobarbital, the females evidencing a depressed desire for food during most of the feeding period. This group never reached the weight peak gained by their controls. The males on sodium phenobarbital had appetites comparable to their controls during the first forty-six weeks of drug feeding, but a depressed desire for food was observed during the last fifty-four weeks.

Reduced activity was observed in the amytal and barbital groups as early as the twenty-fifth week of feeding, being most marked and more progressive in the barbital animals. Both groups used the turntable exercisers much less than did their controls. As will be shown in a later paper, most of the barbital animals refused to run on the maze. The animals in the phenobarbital, alurate and allonal groups did not show any signs of reduced activity in the cage.

Abstinence or renewal symptoms were not observed in any of the groups on barbiturates during or after the following withdrawal periods—

| | | | |
|---|---|---|---|
| Phenobarbital group | for 3 | weeks following | 87 weeks of feeding |
| Barbital group | for 4 | weeks following | 75 weeks of feeding |
| Amytal group | for 4 | weeks following | 75 weeks of feeding |
| Alurate group | for 4.5 | weeks following | 80 weeks of feeding |
| Allonal group | for 4.5 | weeks following | 80 weeks of feeding |

Considering the toxic doses given by Brownlee (*36*), the average of literature minimum lethal dose statements (table 2) and the material presented in this paper, a comparison of relative toxicity for the antipyretics studied is as follows, the drugs being listed in order of increasing toxicity—

Brownlee (36)—antipyrine, phenacetin, aspirin, aminopyrine, acetanilid.

Lit. averages—acetanilid, phenacetin, aspirin, antipyrine, aminopyrine, cincophen.

Our work — aminopyrine, acetanilid, aspirin, cincophen, phenacetin, antipyrine.

For the barbiturates—

Nielson *et al.* (*69*)—barbital, amytal, phenobarbital, alurate.

Lit. averages (table 3)—barbital, phenobarbital, alurate, amytal.

Our work—allonal, amytal, alurate, phenobarbital, barbital.

## THE "ALL" GROUP

This group of eight male rats received nine drugs, each in exactly the same dosage given to the groups receiving only one of the drugs. These nine drugs are underlined in table 1 as are also the doses used for each during the three periods. Attention is called to the fact that these animals received as the maximum dose, for the last 402 days of the experiment, 128.9 mg. of drug per kg. of body weight daily. If we are to consider the statements of Greenman and Duhring (*2*) and others (*3*), (*4*), each rat received the equivalent of 315,600 adult human drug doses over a period equal to 2,580 weeks for human beings (table 2).

The lack of effect of this extended period of medication with a combination of diuretic, laxative, respiratory and cardiac stimulating, antipyretic, analgesic and hypnotic drugs seems nothing short of amazing. While the group revealed some evidence of depressed activity on the maze, this effect of drug medication was not observed to any extent in the cage, although they received the same amount of barbital as did the barbital group. Appetites, as compared to litter-mate controls, were normal throughout the entire feeding period. There was no laxative effect nor was there any of the noisy breathing described for the groups on aspirin.

Although the "All" group received the same daily dose of phenolphthalein given to the phenolphthalein group, and for the same period, none of the peculiar hypersensitivity to touch stimuli observed in the latter group was evidenced in the "All" group.

A period of latent toxicity has been described for the caffeine male, acetanilid, phenacetin and cincophen groups, this toxicity being made evident by a rather marked reduction in appetite, activity and appearance during the last weeks of feeding. Although all of these drugs were included in the "All" group medication, there was very little evidence of this latent toxicity period in the group.

A number of explanations could be given for the lack of toxic effects of this "shotgun" medication in the "All" group. Gilman and Barbour (*93*) have shown that aspirin is antagonistic to phenobarbital, and that antipyrine antagonizes the toxic action of phenobarbital without diminishing its hypnotic effect. Rose (*49*) has shown that the toxicity of aminopyrine is reduced approximately two-thirds when an effective dose of sodium amytal is given at the same time. It is conceivable, therefore, that the toxic effects of the antipyretics might have been antagonized by the presence of bar-

bital in the drug mixture, or, according to Rose, that the reverse be true.

Modifications of solubility and absorbability of the constituent drugs in the mixture are undoubtedly factors involved in an explanation of the absence of toxic effects in the "All" group. Many of the drugs in the mixture contain the benzene ring in the molecule, and it is a well-known fact that the body protects itself from such toxic substances by the formation of hippuric acid. In this connection, Astolfani (*94*) has shown that caffeine increases the amount of benzoate that can be synthesized into hippuric acid.

## DEATH-RATE COMPARISON—RAT "PNEUMONIA"

A death-rate comparison for all groups of rats included in this investigation is presented in table 4. All groups in the colony totaled 204 rats at the beginning of the feeding period, and there were 88 deaths during the experiment, or 43.1 percent of control and test animals. Drugs were administered to 139 rats in seventeen groups and 69 of these animals died during the experimental period as compared to 19 deaths in 65 control animals. On a basis of percent comparison, 50 percent of the test animals died as compared to 29 percent of the controls. It therefore seems evident that the drugs administered during the experiment have exercised, as a group, a considerable degree of toxicity, judging, at least, from a comparison of death rates for control and test animals.

TABLE 4

*Death Rate Comparison for All Groups*

| Drug Group. | Deaths. | Percent deaths in group. | Percent deaths in controls. |
|---|---|---|---|
| Barbital (Na) males | 10 of 13 | 77.0 | 20.0 |
| Phenobarbital (Na) males | 6 of 9 | 66.7 | 22.2 |
| Amytal (Na) males | 6 of 11 | 54.5 | 20.0 |
| Alurate (Na) females | 5 of 10 | 50.0 | 22.2 |
| Phenobarbital (Na) females | 3 of 8 | 37.5 | 37.5 |
| Allonal females | 3 of 9 | 33.3 | 22.2 |
| Antipyrine females | 6 of 9 | 66.7 | 22.2 |
| Aspirin males | 5 of 9 | 55.6 | 22.2 |
| Aspirin females | 4 of 8 | 50.0 | 37.5 |
| Phenacetin males | 3 of 6 | 50 0 | 25.0 |
| Cinchophen males | 3 of 6 | 50.0 | 25.0 |
| Aminopyrine females | 2 of 9 | 22.2 | 22.2 |
| Acetanilid males | 1 of 6 | 16.7 | 25.0 |
| Phenolphthalein males | 3 of 4 | 75.0 | 25.0 |
| Caffeine males | 4 of 7 | 57.0 | 43.0 |
| Caffeine females | 3 of 7 | 43.0 | 40.0 |
| "All" group males | 2 of 8 | 25.0 | 25.0 |
| All test animals | 69 of 139 | 50.0 | 29.1* |

* 19 deaths in 65 controls in entire colony.

As is seen in table 4, the highest death rate for all groups was experienced by the barbital group, only three of thirteen surviving the medication. The acetanilid group suffered the least deaths of all groups, test and control, with only one death in a group of six.

Considering the comparisons presented in table 4, there seems to have been a significant increase in the percent of deaths in the following test groups as compared to controls—sodium barbital, sodium phenobarbital males, amytal, alurate, antipyrine, aspirin males, phenacetin, cincophen and phenolphthalein.

Significant variations in the percent of deaths did not occur in the following test groups—allonal, aspirin females, aminopyrine, acetanilid, caffeine and "All" group. The fact that the percent of deaths was higher in both caffeine groups, male and female, than in the controls may be of some significance.

So-called "rat pneumonia" was responsible for 55.7 percent of all deaths in the colony during the experiment. The progress of the disease was much more rapid in our experience than in that of Greenman and Duhring (*2*), who have described a period of unnatural, noisy, labored breathing at the onset of the disease. In forty-nine cases of pneumonia observed during this investigation there has been no sign of noisy breathing, but rather an apparent complete absence of breathing when the disturbance was first noticed, usually in the morning. In a number of instances the nostrils have been completely closed by the finger and little or no passage of air could be detected. The normal rat will not permit such treatment even for a second, but the pneumonia rat seemed to suffer no added discomfort even after minutes. This is taken as proof that the pneumonia rat was unable to breathe through the nose. The animals, as a rule, died in a few hours, presumably from suffocation.

We have, in a number of cases, cleared the nostrils with an ephedrine inhalant, and have been able to keep some of the animals alive for as long as a week by feeding warm milk chocolate from a medicine dropper.

Many of the animals were examined carefully after death, and in every instance the lungs were found to be badly congested with a watery fluid and the air passages completely closed by swelling. All of the abdominal contents had a bad odor even though the disease had been of but a day or so in duration. The blood was thick and dark in color and clotted almost immediately. Bacteria were cultured from the lung contents.

A comparison of deaths due to pneumonia is presented in table 5,

the barbiturate groups being listed first in order of decreasing percent. Next are listed the antipyretic-analgesic drug groups followed lastly by other drugs, *i. e.*, nonbarbiturate, nonantipyretic, including, however, the "All" group which received both.

TABLE 5

*Deaths Due to Pneumonia*

| GROUP. | Group No. | Rats in group. | Total deaths. | Pneumonia deaths. | Pneumonia deaths percent of total deaths. | Pneumonia deaths percent of group. |
|---|---|---|---|---|---|---|
| Barbital (Na) | 1 | 13 | 10 | 10 | 100.0 | 77.0 |
| Phenobarb. (Na) males | 3 | 9 | 6 | 4 | 66.7 | 44.4 |
| Alurate (Na) | 4 | 10 | 5 | 4 | 80.0 | 40.0 |
| Amytal (Na) | 1 | 11 | 6 | 4 | 66.7 | 36.4 |
| Phenobarb. (Na) females | 6 | 8 | 3 | 2 | 66.7 | 25.0 |
| Allonal | 4 | 9 | 3 | 2 | 66.7 | 22.2 |
| Antipyrine | 5 | 9 | 6 | 4 | 66.7 | 44.4 |
| Phenacetin | 2 | 6 | 3 | 2 | 66.7 | 33.3 |
| Aspirin males | 3 | 9 | 5 | 2 | 40.0 | 22.2 |
| Cincophen | 2 | 6 | 3 | 1 | 33.3 | 16.7 |
| Aspirin females | 6 | 8 | 4 | 1 | 25.0 | 12.5 |
| Aminopyrine | 5 | 9 | 2 | 1 | 50.0 | 11.1 |
| Acetanilid | 2 | 6 | 1 | 0 | 0.0 | 0.0 |
| Pheno'phthalein | 2 | 4 | 3 | 2 | 66.7 | 50.0 |
| Caffeine males | 8 | 7 | 4 | 1 | 25.0 | 14.3 |
| Caffeine females | 7 | 7 | 3 | 1 | 33.3 | 14.3 |
| "All" group | 2 | 8 | 2 | 1 | 50.0 | 12.5 |
| Controls for | 1 | 10 | 2 | 1 | 50.0 | 10.0 |
| Controls for | 3 | 9 | 3 | 2 | 66.7 | 22.2 |
| Controls for | 4 | 9 | 2 | 1 | 50.0 | 11.1 |
| Controls for | 6 | 8 | 3 | 1 | 33.3 | 12.5 |
| Controls for | 5 | 9 | 2 | 0 | 0.0 | 0.0 |
| Controls for | 2 | 8 | 2 | 1 | 50.0 | 12.5 |
| Controls for | 7 | 5 | 2 | 1 | 50.0 | 20.0 |
| Controls for | 8 | 7 | 3 | 0 | 0.0 | 0.0 |

It was evident quite early in the experimental period that many of the barbiturate animals were dying with pneumonia. This was especially true in the barbital group in which there were ten deaths, all of them due to pneumonia, 77.7 percent of the entire group. As is shown in table 5, the pneumonia death rate was higher in all groups on barbituric acid derivatives than in their respective controls. The difference is least marked in the phenobarbital female and allonal groups. Allonal, as has been stated, contains aminopyrine and alurate. It should be noted that the percent of deaths due to pneumonia was nearly four times as high in the alurate group as in the controls, while in the allonal group it was only twice as high. This seems to suggest that aminopyrine had reduced the

toxicity of alurate. The table also shows that the percent of pneumonia deaths was very low in the aminopyrine group.

Of the antipyretic-analgesic drugs, a significant increase in the percent of pneumonia deaths is apparent only in the antipyrine and phenacetin groups. Attention is again called to the close chemical relationship between these two drugs and aminopyrine and acetanilid, respectively, and to the fact that only 11.1 percent of the aminopyrine group and none of the acetanilid group died with pneumonia.

The phneolphthalein group suffered a percent pneumonia death loss second to the barbital group. The authors are aware that the group was small, but are also of the opinion that this lack of numbers in the cage should have favored the group if it had any effect.

The pneumonia death percents in the caffeine groups show no significant variations, being higher in the males and lower in the females than in their respective controls. Both are, however, higher than the percent of pneumonia deaths shown for all controls in table 6.

The "All" group experienced the low pneumonia death percent of 12.5 as compared to the high percents of 77.7, 44.4, 33.3 and 50 in the barbital, antipyrine, phenacetin and phenolphthalein groups. The "All" group received all of these drugs as well as aminopyrine and acetanilid (and others, table 1). Aminopyrine and acetanilid may have protected these animals from the toxic effects of the drugs listed above as aminopyrine seems to have done in the allonal group. There were no pneumonia deaths in the acetanilid group.

TABLE 6

*Comparison of Pneumonia Deaths by Drug Groups*

| CLASS OF DRUG. | Rats in Group. | Total deaths. | Pneumonia deaths. | Pneumonia deaths percent of total deaths. | Pneumonia deaths percent of group. |
|---|---|---|---|---|---|
| Barbiturate | 60 | 33 | 26 | 79.0 | 43.3 |
| Antipyretic | 53 | 24 | 11 | 45.8 | 20.8 |
| Phenolphthalein | 4 | 3 | 2 | 66.7 | 50.0 |
| Caffeine males | 7 | 4 | 1 | 25.0 | 14.3 |
| Caffeine females | 7 | 3 | 1 | 33.3 | 14.3 |
| "All" group | 8 | 2 | 1 | 50.0 | 12.5 |
| Colony controls* | 65 | 19 | 7 | 37.0 | 11.1 |
| All test groups | 139 | 69 | 42 | 60.9 | 30.2 |
| Male controls | 34 | 10 | 4 | 40.0 | 11.7 |
| Female controls | 31 | 9 | 3 | 33.3 | 9.7 |

* All controls in the colony combined.

A comparison of pneumonia deaths by classes of drugs is presented in table 6, and there seems little question concerning the effect of the barbiturates in increasing the incidence of pneumonia in rats. The table shows that 43.3 percent of all animals on barbiturates died with pneumonia and that 79 percent of all deaths in these animals were due to the disease. The percent of pneumonia deaths was more than twice as high in the barbiturate groups as in the antipyretic groups and more than four times as high as in the combined control groups. Also, seventy-nine percent of deaths in the barbiturate groups were due to pneumonia as compared to 37 percent in the combined controls. That this high percent of pneumonia deaths in the barbiturate animals was not due to sodium barbital alone is shown by the fact that, exclusive of sodium barbital, 70 percent of barbiturate deaths were due to pneumonia and 34 percent of the animals on barbiturates, excluding sodium barbital, died with the disease.

Table 6 shows that the pneumonia death percent of the group was nearly twice as high in animals on antipyretic-analgesic drugs as in the combined control group. However, the percent pneumonia deaths of total deaths is only slightly more than one-fifth higher in the antipyretic groups as in all colony controls.

Table 6 shows that the male and female caffeine groups and the "All" group experienced low pneumonia death rates as compared to the combined controls and to other groups.

One additional point should be mentioned concerning the barbiturate animals and pneumonia. We have already stated that some of the pneumonia animals could be kept alive for as long as a week by the application of ephedrine inhalant to the nostrils and forced feeding with warm milk chocolate. The barbiturate animals with pneumonia did not respond to this treatment. There seems to have been plenty of evidence to warrant the conclusion that the disease was more severe, as well as more frequent, in the rats on barbiturates.

## POST-MORTEM EXAMINATION

All animals surviving the drug feeding periods (table 4) were killed and the internal organs subjected to careful macroscopic examination. Particular attention was given to the stomach and intestinal linings, the lungs and air passages, liver, kidneys and spleen. In no instance were abnormalities observed that would differentiate the organs of test animals from those of litter-mate controls.

## SUMMARY

Thirteen rather commonly used drugs have been administered orally to the Wistar strain of albino rat during what has been the life cycle for the majority of the animals. Dosage has been based on the average daily dose for a 70 kg. human. All rats were thoroughly tamed and adequately fed and housed. Litter mates were used as controls for all test groups. A summary of results is presented in table 7.

Attention is especially called to the fact that, of the thirteen drugs used during the investigation, aminopyrine alone failed to produce some evidence of toxicity either in the living animal or through an increase in the death rate. Of six antipyretic-analgesic drugs, aspirin was the only one to produce an effect that was noticeable to the casual observer. Aspirin medication caused a noisy, unlabored breathing in both sexes during about the tenth to the thirty-fifth weeks. A laxative effect with a soft, light-colored stool was observed during this same period. Antipyrine, like aminopyrine, caused no observable effects in the living animals, but did increase the death rate in the group rather markedly. Acetanilid and phenacetin caused no observable effects during the first 72 weeks of feeding, but marked decreases in appetite, activity and appearance were observed during the last 14 weeks. The death rate in the acetanilid group was lower than in the controls, while it was much higher than in the controls in the phenacetin group. Cincophen, like acetanilid and phenacetin, caused no observable effects during the first 65 weeks, but toxic effects were markedly apparent during the last 20 weeks. The percent of deaths due to pneumonia was increased rather markedly in the antipyrine and phenacetin groups, but not in the aspirin, cincophen, aminopyrine and acetanilid group.

Of five barbiturates, including allonal, only sodium phenobarbital had a significant effect on appetites, reducing the desire for food in both sexes, but more especially in females. Sodium barbital and sodium amytal caused a rather marked decrease in activity, sodium barbital being most effective in this respect. Allonal and sodium alurate had no observable effect on the living animal.

All barbiturates caused an increase in the death rate, sodium barbital being most effective and allonal least. The percent of total deaths due to pneumonia was increased in all groups on barbiturates, 100 percent of all rats dying in the sodium barbital group dying with this disease. Forty-three percent of all rats in the barbiturate groups died with pneumonia as compared to 21 percent in the anti-

TABLE 7

*Summary of Results*

| Drug Group. | Sex. | Activity. | Appetite. | Feces. | Toxicity (observed in cage). | Withdrawal symptoms. | Total death-rate. | Pneumonia death-rate. | Autopsy termination. |
|---|---|---|---|---|---|---|---|---|---|
| Barbital Sodium | M | Marked decrease | Normal | Normal | Slight | None | Marked increase | Marked increase | Normal |
| Phenobarb. Sodium | Both | Normal | Reduced | Normal | Slight | None | Increase in males | Increase | Normal |
| Alurate Sodium | F | Normal | Normal | Normal | None | None | Increase | Increase | Normal |
| Amytal Sodium | M | Decrease | Normal | Normal | Slight | None | Increase | Increase | Normal |
| Allonal | F | Normal | Normal | Normal | None | None | Slight increase | Slight increase | Normal |
| Antipyrine | F | Normal | Normal | Normal | None | None | Marked increase | Marked increase | Normal |
| Phenacetin | M | No effect for 72 weeks | No effect for 72 weeks | Normal | Marked after 72 weeks | None | Increase | Increase | Normal |
| Cincophen | M | No effect for 65 weeks | No effect for 65 weeks | Normal | Marked after 65 weeks | None | Increase | Normal | Normal |
| Aspirin | Both | Normal | Normal | Light color and soft | Noisy breathing | None | Increase | Normal | Normal |
| Aminopyrine | F | Normal | Normal | Normal | Normal | None | Normal | Normal | Normal |
| Acetanilid | M | Normal for 72 weeks | Normal for 72 weeks | Normal | Marked after 72 weeks | None | Below controls | Below controls | Normal |
| Phenolphthal | M | Decrease | Decrease | Normal | Marked | Marked | Marked increase | Increase | Normal |
| Caffeine | Both | Increase in females | Increase in females | Normal | After 90 wks. in males | None determined | ? | ? | Normal |
| "All" group | M | Normal | Normal | Normal | None | None | Normal | Normal | Normal |

pyretic, analgesic drug groups and 11 percent in all controls in the colony.

Rats on phenolphthalein showed evidences of toxicity as early as the tenth week by sluggishness, reduced desire for food and altered appearance. A hypersensitivity to touch stimuli was observed at about the twentieth week, progressing to such a degree that it was almost impossible to catch the animals. This peculiarity was not observed in any other group in the colony. Phenolphthalein was next to sodium barbital in toxicity as judged from the death rate. There was never any evidence of a laxative effect as a result of the medication, although phenolphthalein was identified in the feces at different periods.

Caffeine caused a marked increase in activity and an apparent increase in the desire for food in females, but not in males. A high degree of toxicity was observed in the males on caffeine at about the one hundredth week as evidenced by a marked reduction in activity, appetites and general appearance. This latent toxicity was not observed in the females on caffeine. The death rate was higher in both caffeine groups than in their respective controls, and significantly higher than in the combined colony controls.

The "All" group was a group of male rats receiving barbital as a representative of the barbiturates, plus caffeine, phenolphthalein, aminopyrine, antipyrine, acetanilid, phenacetin, aspirin, and cincophen, all in exactly the same dosages given to the groups receiving the drugs individually. There was no evidence of toxicity in the group at any time during the eighty-six-week feeding period and the death rate or the percent of pneumonia deaths were not increased in spite of the fact that each rat in the group received the equivalent of 315,600 adult human doses over a period equivalent to 2,580 weeks in the human. The combination of nine drugs proved less toxic to rats than any of the drugs administered singly.

Withdrawal or renewal symptoms were not observed in any of the drug groups with the exception of phenolphthalein, the latter evidencing some reduction of excessive sensitivity to touch stimuli during a five-week abstinence period.

Macroscopic post-mortem examinations performed on all surviving animals revealed no abnormalities that would differentiate any of the test animals from the controls.

Judging from observed toxic effects evidenced during the period and from the death rate, the authors would list the drugs included in the investigation as follows, in order of increasing toxicity—

Antipyretic-analgesics—

aminopyrine, acetanilid, aspirin, cincophen, phenacetin, antipyrine.

Barbiturates—

allonal, amytal, alurate, phenobarbital, barbital.

Phenolphthalein, as used in this study, is considered just below barbital in toxicity, and caffeine just below aspirin.

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THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XXVII] NOVEMBER 1, 1941 [No. 4

# A New Anuran from the Middle Miocene of Nevada

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ABSTRACT: A new fossil Anuran, *Miopelodytes gilmorei,* is described as a new genus and species. The form is most closely related to *Pelodytes punctatus* and *P. caucasicus* of southern Europe and southwestern Asia. The family PELODYTIDAE Cope is revived to receive the two genera, excluding other forms placed in it by Cope.

A FOSSIL toad preserved in a shale slab, and representing a new genus, has been placed in my hands for study by Dr. Charles W. Gilmore of the United States National Museum. The specimen is remarkable not only because so many significant skeletal characters are discernible (the specimen prior to collection seemingly having been preserved perfectly), but also because there is unmistakable imprint of the skin so that in a measure the character of the skin and the body outline is indicated. Moreover, it is the second oldest Anuran discovered in the Western Hemisphere, and is the only extinct member of the family PELODYTIDAE known and its only representative in the Western Hemisphere.

With the cleaving of the slab to expose the enclosed animal, the soft fossilized bone has crumbled in many places, leaving only a powdery remains. However, the imprint of the bones is clear in many places and serves to delineate the original features. Nevertheless, many important characters of the skull and the characteristics of the centra of the vertebrae cannot be determined.

## *Miopelodytes* gen. nov.

Characterized by the absence of free ribs; eight presacral vertebrae; sacral vertebrae with greatly widened diapophyses, presumably free from coccyx; epiphyses of long bones cartilagenous; coccyx apparently composed of more than a single element; proximal tarsals fused into a single bone; prehallux absent.

*Miopelodytes gilmorei* sp. nov.*

*Type specimen.* U. S. N. M., No. 12356. Consists of entire skeleton preserved in shale slab (portion of right arm missing). Collected by W. L. Sheeler, and donated to the Museum by R. M. Catlin.

*Type locality.* R. 55 E., T. 34 N. Near the town of Elko, Nevada.

*Horizon.* Elko Shales, Middle Miocene.

*Description.* The animal lies on its back, and the ventral bones of the skull and the ventral surfaces of most of the elements are wanting at the present time. It is probable that they may have been attached to the other half of the slab after cleaving. Whether or not this part is in existence I do not know.

The head-body length of the fossil is 51 mm. from the premaxillae to the end of the ischium. The hind limb is about 85 mm. in total length. These measurements represent rather closely the actual length.

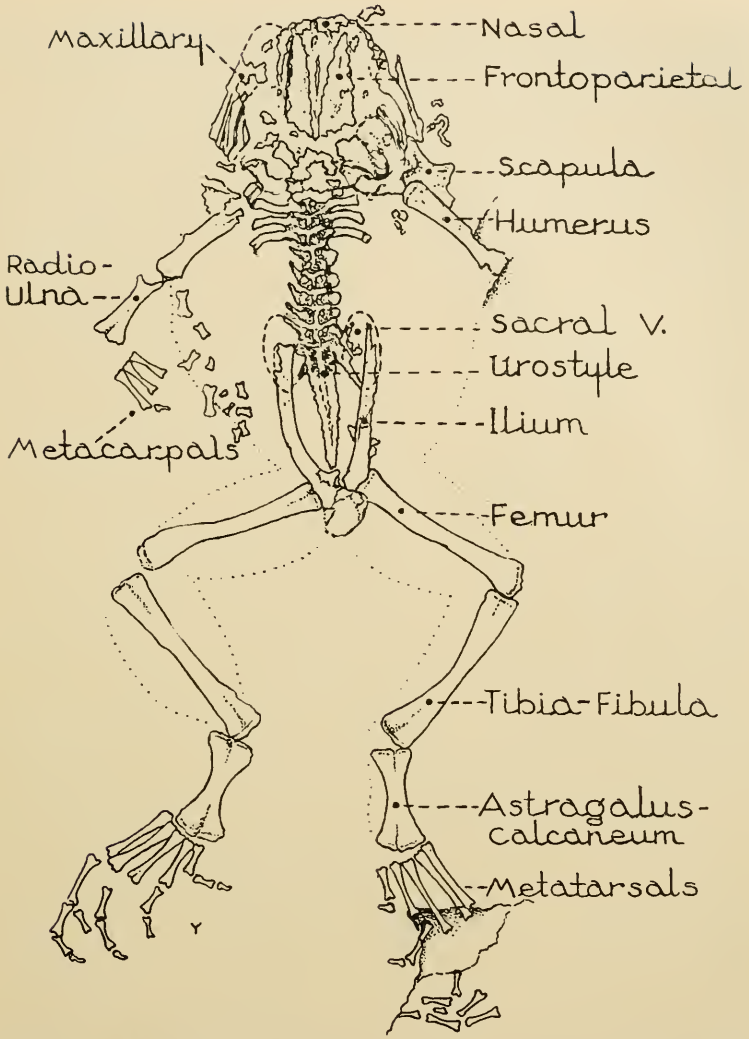
*Skull.* All the elements of the cranium are fragmentary, and the parts remaining have the consistency of a greasy powder. All the ventral skull bones apparently are absent and the maxillae and premaxillae are represented only by their more dorsal portions. Thus there is no evidence of teeth, although it is highly probable that they were originally present. There is a trace of the posterior part of the right mandible showing a posterior flexure. The outlines of the frontoparietals show them as elongate triangular bones, separated medially by a narrow fontanelle. Judging from the position in which they lie, there appears to have been a groove or depression on the dorsal surface of the head. Along the anterior tip of the right frontoparietal is a tiny fragment bearing two conical teeth lying loose. I believe this to be a fragment of a prevomer (although it may be a broken fragment of one of the upper jaw bones). The imprint of the posterior part of the skull presents a very uneven surface, but no significant details can be ascertained.†

*Pectoral girdle and limb.* The scapula of the left side is nearly intact. It is seen from the ventral surface, and is of typical shape. A minute fragment of the suprascapula adjoins it at the outer end. The characters of the clavicle, coracoid, and sternal elements cannot be determined.

The humerus is of ordinary shape articulating with the rounded socket of the radio-ulna. The distal end of the latter element is clearly defined. Between the radio-ulna and metacarpals are de-

* The species is named for Dr. Charles W. Gilmore of the United States National Museum.

† If the powdery remnants of the bone were to be removed from the matrix and a cast made, the characters of the dorsal skull surface could easily be obtained.




TEXT FIG. 1. *Miopelodytes gilmorei* sp. nov. U. S. N. M. No. 12356. Middle Miocene, Elko shales. Near Elko, Nev. An outline of the bones.

pressions suggesting the presence of at least four carpals. These apparently were cartilage as such fragments as remain are infiltrated with a black crystalline mineral like that found in the epiphyses of the longer bones. Three outer metacarpals remain, as well as a dim imprint which may represent the first metacarpal. The phalanges are displaced on the right hand, while the whole lower arm is missing on the left side.

*Pelvic girdle and limb.* The pelvic girdle is represented by the ilia and at least a part of the pubo-ischial complex. The two latter elements cannot be differentiated. However, there is a slight notch apparent suggesting that the pubis was cartilage (or possibly wanting). The ilia curve slightly and are attached nearly the length of the elongate sacral diapophyses. The femora are slightly curved and traces of the cartilagenous epiphyses are evident, infiltrated with a black crystalline mineral. The double character of the tibia-fibula is evident. The proximal tarsals are fused together throughout their length, greatly narrowed medially, and widened at each end where the bifid character is well defined. The toes are rather long. The formula of the phalanges (right foot) is 2-2-3-4-?; the terminal phalanges are cylindrical and taper to an oval pointed tip. I find no trace whatever of distal tarsals or of a prehallux.

*Vertebrae.* The fragmentary vertebrae are nine in number,* eight preceding the sacral vertebra, which has greatly dilated diapophyses that present a curving outer edge (save for some fragments these diapophyses are represented by a rather clear imprint on the matrix). The processes of the second to fourth vertebrae are about the same length, the second curved slightly forward, the fourth curving back, slightly; the succeeding vertebrae have very short slender processes directed obliquely forward. I cannot determine positively whether the urostyle is fused to, or articulated with the sacrum, although it appears to articulate. There is evidence that there is a partial separation of the anterior part of the urostyle as if it were composed of a more or less separate vertebra and a urostyle.

*Measurements in mm.* Estimated length of head-body, 57; actual length of bones in situ, 51; length of skull, 17; width of skull (perhaps somewhat distorted), 23; humerus, 12.5; radio-ulna, 9.5; femur, 19; tibia-fibula, 19.2; astragulo-calcaneum, 10.5; metatarsals in order, 4, 5.8, 7.8, 8, 7.2; length of fourth toe, 21.4; third toe, 16; length of ilium and ischium combined, estimated, 20.5; length of urostyle to posterior end of sacral vertebra, 13; width of third vertebra, 10.8.

*Skin.* The outline of the body is evident in the darkened area, visible in the photograph, suggesting that the animal was squat and toadlike. From the width of the femoral and tibial regions it is probable that this has been flattened and widened by pressure. That the skin was irregularly granulate or tuberculate is evidenced by

* The first (atlas) vertebra is fused with the second.

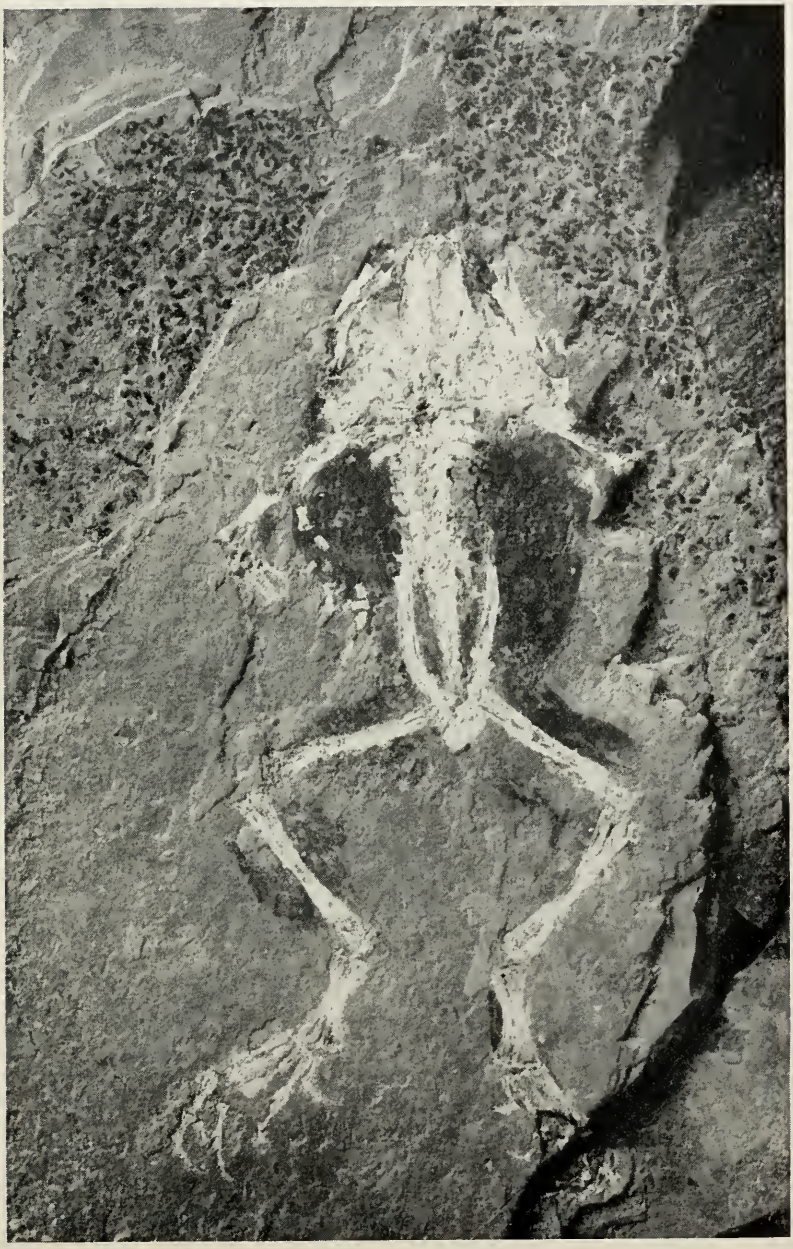


PLATE I. *Miopelodytes gilmorei* sp. nov. U. S. N. M. No. 12356. Type. Middle Miocene, Elko shales, Elko, Nev. (Photo by courtesy of the United States National Museum.)

irregularities on the surface clearly distinguishable to the naked eye. This skin material forms an extremely thin layer which is easily dislodged.

*Remarks.* Since the described animal appears to be most closely related to a living European genus *Pelodytes* it seems pertinent to review the classification of this and other genera associated with it. Nicholls and Noble have revised the classification of the frogs primarily on the basis of the salient characters of the vertebrae. The arrangement of Noble (1931) divides the Anura (Salientia) into five suborders.

I. AMPHICOELA (Amphicoelous vertebrae).

II. OPISTHOCOELA (Opisthocoelous vertebrae; free ribs in larvae or adults).

III. ANOMOCOELA (Vertebrae variable; sacral vertebrae procoelous, fused to coccyx or free with either single or double condyle; presacral vertebrae procoelous or with free intervertebral disks).

IV. PROCOELA (Procoelous vertebrae; double condyle on coccyx—rarely fused).

V. DIPLASIOCOELA (Sacral vertebrae centrum convex anteriorly, preceded by the eighth vertebra, which is biconcave and preceded by seven procoelous vertebrae).

We are especially concerned here with the presumedly more primitive groups associated by Noble with the first three suborders.

Order Salientia
- Suborder I. Amphicoela
  - Family Liopelmidae
- Suborder II. Opisthocoela
  - Family Discoglossidae
  - Family Pipidae
    - Subfamily Xenopinae
    - Subfamily Pipinae
- Suborder III. Anomocoela
  - Family Pelobatidae
    - Subfamily Megophryinae
    - Subfamily Pelobatinae
    - Subfamily Sooglossinae

Our concern is chiefly with the suborder III, Anomocoela. In it is placed the single family PELOBATIDAE (which equals the families SCAPHIOPODIDAE and PELOBATIDAE of recent authors and the PELODYTIDAE of Cope).

This is divided into three subfamilies:

I. *Megophryinae*, Pelobatids with free intervertebral disks or the free intervertebral disks more or less exposed, including

*Megophrys* [= *Megalophrys* and *Leptobrachium*], *Nesobia, Scutiger, Aelurophryne, Ophryophryne, Leptobrachella;* Indian, South Asia and the Indo-Australian region, the Philippines and Natuna Islands (not reaching New Guinea).

II. *Pelobatinae.* "Pelobatids with presacral vertebrae uniformly procoelous, sacrum fused to the coccyx except in *Pelodytes* which has a single condyle" (sic, *in errore*). This includes *Pelobates, Scaphiopus* and *Pelodytes.* North America to Central America, Europe and Asia.

III. *Sooglossinae.* Pelobatids with a free coccyx, a horizontal pupil and a ranid type of thigh musculature. Seychelles Islands, Indian Ocean.

The placing of the genus *Pelodytes* in the family *Pelobatidae,* and more especially in the subfamily *Pelobatinae,* is without regard for numerous very important characters. As is seen from the definition of the suborder, it is something of a catch-all.

The genera *Scaphiopus* and *Pelobates* agree in the fusion of the sacral vertebra and the coccyx, in the more strongly roofed skull, with the pitted "stegocephalian type" of bone surface appearing frequently, the separate astragalus and calcaneum, the presence of a large bony prehallux forming a spade, and their general toadlike appearance; the first two vertebrae are not fused.

On the other hand, *Pelodytes* has a slender, fragile, reduced type of skull, with smooth bones, the palatine bone wanting, astragalus and calcaneum fused, and a minute cartilagenous prehallux, not forming a spade. The coccyx does not fuse with the sacral vertebrae, but articulates by a double condyle; first two vertebrae fused. The habitus is slender, froglike.

The fossil history of the group here associated in the PELOBATIDAE (of Noble) is very fragmentary. However, at least representatives of three groups are known. Noble (1924) described a spade-foot toad from the Oligocene of Mongolia, *Macropelobates osborni* (new genus and species), as follows: "Undoubtedly a pelobatid in that it exhibits the following characters: anomocoelous, with coccyx not ankylosed to sacrum; coccyx with a single condyle; teeth present on upper jaw; coracoids suggesting an arciferal condition; an enormous prehallux (spade); epiphyses absent (cartilagenous); a bony incrustation on the frontoparietal, nasal, and squamosal." Thus it appears that this, the oldest known form, bears a close resemblance to *Pelobates.* The free coccyx with single condyle is significant, but this is occasionally present in some species of *Pelobates.* The astragalus and calcaneum are separate and there is no approach to the characters of *Pelodytes* or *Miopelodytes.*

Parker (1929) has described the genus *Eopelobates* from the Miocene beds of Roth, near Bonn, Germany. While he does not definitely refer it to the family PELOBATIDAE he suggests that a relationship exists, pointing to several characters that link it with the pelobatids and offering none that disclaim the relationship save the absence of a prehallux, and the shorter proximal phalanges. Here the astragalus and calcaneum are entirely distinct.

I have described (Taylor, 1936, 1939) two fossil species from the Pliocene, which have been referred to the genus *Scaphiopus*. There is nothing in these forms to throw light on the relationships of the American forms that is not evident in living forms.

The complete fusion of the radius and ulna, and of the tibia and fibula constitute probably one of the oldest Anuran characters. It very probably appeared in some caudate ancestor. These elements have every appearance of being fused in the caudate form of uncertain relationship known as *Pelion lyelli* Wyman (1858, and Moodie 1916, Pl. 24, fig. 1) from the coal measures of Linton, Ohio. So far as I know, no Anuran has brought about the separation of these elements. I conceive that the fusion of the astragalus and calcaneum was a continuation of the ancient fusion of the more proximal parts of the limbs and has been retained today only in *Pelodytes*. I would expect to find this condition present in the earliest definitive Anura and later ones prior to the assumption of the leaping habit. I believe that the separation of the astragalus and calcaneum was a later development, brought about by the leaping habit.

Whether the oldest known frog *Eobatrachus agilis* Marsh from the Jurassic had these elements fused has not been determined. The fact that Moodie (1912) placed the form in the BUFONIDAE is not significant for, on the basis of his material, it might just as easily have been placed in any one of several other families.

Cope's Family PELODYTIDAE included two genera, *Leptobrachium* and *Pelodytes*. He defined the family as follows: "Vertebrae procoelian; no ribs or diapopyses of coccyx. Sacrum united with the coccyx by condyle, its diapophyses thin and largely dilated. Xiphisternum an osseous style, with terminal disk. External metatarsi bound together." *

His concept of the family was again modified, and later† he includes *Xenophrys* and *Batrachopsis* in the family.

* Cope, Journ. Acad. Nat. Sci. Phila., (2) VI, 1866, p. 80.
† Cope, Bull. U. S. Nat. Mus., 34, 1889, p. 296.

The proposed disposition of the two genera *Pelodytes* and *Miopelodytes* is as follows:

Family PELODYTIDAE Cope, 1866 (excluding all genera save *Pelodytes*).

*Pelodytes* Fitzinger (1838).

*Miopelodytes* Taylor (1941).

The following characters should be included as family characters: Astragulus and calcaneum fused; two anterior vertebrae fused.

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THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XXVII] NOVEMBER 1, 1941 [No. 5

# A New Pycnodont Fish from the Upper Cretaceous of Rooks County, Kansas

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ABSTRACT: A new Pycnodont fish, *Pycnomicrodon kansasensis, gen. et sp. nov.* is described from the Upper Cretaceous of Kansas. The type is based on the anterior part of the skull, a few scales posterior to the opercular region, and prevomer with teeth.

THE remains of Pycnodont fish have rarely been found in the Cretaceous of Kansas. Williston (Kan. Univ. Quart. IX, No. 2, 1900, pp. 28-29) reported a fragment of the left lower jaw containing two rows of teeth of *Coelodus brownii* Cope and a fragment of the right lower jaw of *Coelodus stantoni* Williston from the Kiowa shales of Kansas. Cragin (Colorado College Studies, V, 1894) described *Macromesodon abrasus* (Cragin) based on isolated teeth taken from his "No. 3 of the Belvidere section," of the Kiowa shale, Lower Cretaceous.

Not until 1939 were the remains of Pycnodont fish discovered in the Upper Cretaceous of Kansas. Hibbard (Univ. Kan. Sci. Bull., Vol. 26, No. 9, 1939) described *Coelodus streckeri* from Russell county, Kansas, based on a prevomer with teeth. In the summer of the same year the junior author collected the remains of a Pycnodont fish from an exposure of Niobrara chalk one mile west of Webster, Rooks county, Kansas. The following report is based on this specimen.

We are indebted to Dr. H. H. Lane, curator of museums, for much helpful criticism and advice.

*Pycnomicrodon* gen. nov.

*Genotype.* *Pycnomicrodon kansasensis* sp. nov., No. 1019F, Kansas University, Museum of Vertebrate Paleontology. Prevomer plate complete with parasphenoid; anterior part of skull with roofing bones; and associated anterior scales.

*Diagnosis.* The characters of the genus are those of the type species.

*Pycnomicrodon kansasensis* sp. nov.

(Plate 1, figs. 1-4)

*Holotype.* No. 1019F, Kansas University, Museum of Vertebrate Paleontology. Prevomer plate complete with parasphenoid; anterior part of skull with roofing bones; and associated anterior scales. Collected by Allen Graffham, June, 1939.

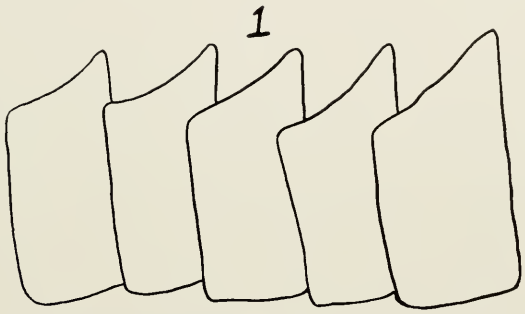
*Horizon and type locality.* Niobrara, Upper Cretaceous, 1 mile west of Webster, Rooks county (locality No. 2), Kansas. Found approximately eight feet above base of a thirty-foot chalk exposure.

*Diagnosis.* A pycnodont fish possessing smooth, rhombic scales posterior to the opercular region, membrane bones ornamented with fine round granulations ending in a blunt point; prevomer small, not notched posteriorly as in *Coelodus;* five rows of teeth present on the prevomer; the transverse width of the prevomer teeth greater than the anteroposterior diameter; the smooth prevomer teeth of the median row set close together and not widely spaced.

*Description of holotype.* Scales imbricated and smooth, in region posterior to opercular. These scales measure in length 15.8 mm., and in width 8.6 mm. Anterior part of skull present, bearing dermethmoid and frontals. Sutures are plain under granulated dermal covering. The small prevomer bears five rows of smooth uncrenulated acrodont teeth. The prevomer is flat and not convex as in *Coelodus streckeri* from the Upper Cretaceous of Russell county, Kansas. The prevomerine dentition presents a slight convexity, owing to the greater height of the crowns of the median row of teeth. The median row of teeth is longer than the lateral rows. The greatest width of the prevomerine dental series is 14 mm. The median row of teeth, seven in number, measures 17.7 mm. in length. In the posterior part of the row the first five teeth are ellipsoid, the sixth and seventh are nearly round. The crowns of the teeth bear no apical depressions, are not crenulated near the base and are entirely smooth except the most anterior tooth of the row, which bears seven rounded minute elevations in the enamel of the crown. The measurements

of the teeth of the median row are taken from the posterior to the anterior; first posterior tooth, transverse width 3.3 mm., anteroposterior diameter 2 mm.; second tooth, transverse width 4.3 mm., anteroposterior diameter 2.5 mm.; third tooth, transverse width 4.2 mm., anteroposterior diameter 2.5 mm.; fourth tooth, transverse width 3.9 mm., anteroposterior diameter 2.6 mm.; fifth tooth, transverse width 3.3 mm., anteroposterior diameter 2.3 mm.; sixth tooth, transverse width 2.6 mm., anteroposterior diameter 2.4 mm.; seventh tooth, transverse width 2.5 mm., anteroposterior diameter 2.05 mm.

The right internal lateral row of teeth, seven in number, is shorter than the median row, measuring 16.4 mm. The teeth are more rounded than the ellispoidal teeth of the median row. The first pos-




Text Fig. 1. *Pycnomicrodon kansasensis* Hibbard and Graffham, drawing of scales posterior to the opercular region, No. 1019F, × 1 approx.

terior tooth is opposite the second posterior tooth of the median row. The second tooth is larger than the first and rests directly against it. It has a greater anteroposterior diameter than the third posterior tooth of the median row, but is opposite to it. The third tooth is smaller than the first, more rounded and alternates with the third and fourth tooth of the median row. The fourth tooth has a greater transverse width than the third, but a shorter anteroposterior diameter, being more ellipsoidal in outline. It alternates with the fourth and fifth tooth of the median row. The fifth tooth is ellipsoidal in outline, but smaller than the fourth. It alternates with the fifth and sixth tooth of the median row, but is closer to the fifth than the sixth tooth of this row. The sixth tooth is nearly round and smaller than the fifth. It is opposite the sixth tooth of the median row. The seventh tooth is the smallest of the series and opposite the larger seventh tooth of the median row. Also, present on its crown are a few minute elevations.

The left internal lateral row with eight teeth in number, shorter than the median row, but longer than the right internal lateral row, measures 16.7 mm. in length. In shape the teeth correspond with those of the left internal lateral row. The first posterior tooth is alternate with the first and second of the median row, though closer to the first than the second. Its base is more posterior than the corresponding tooth of the opposite row. The second tooth is opposite the second posterior tooth of the median row. The tooth is crowded out of the tooth row due to the increase in number of teeth in this row. In position it is the third tooth of the left internal lateral row and the first posterior tooth in the left outer lateral row. The third tooth is alternate with the second and third teeth of the median row. The fourth, fifth, sixth, and seventh teeth are also alternate with those of the median row. Note that the sixth tooth of the right internal lateral row which corresponds to the seventh of the left internal lateral row is opposite the sixth tooth of the median row. The eighth tooth is opposite the seventh tooth of the median row. It is the smallest tooth in the dental series and bears a few minute elevations on its crown.

The right outer lateral row begins alternate with the first and second tooth of the right internal lateral row and extends forward so that the most anterior tooth of the row alternates with the sixth and seventh of the right internal lateral row. The row consisted of seven teeth; the two most anterior are missing. The remaining five teeth measure 9.5 mm. in length. The teeth are normal except the second posterior, which is strongly ellipsoidal. This tooth is opposite the well-developed second posterior tooth of the right internal lateral row, which probably influenced its development.

The left outer lateral row consists of six teeth measuring 10.5 mm. Posteriorly it begins opposite the third tooth of both the left internal row and the median row. The anterior tooth of this row terminates opposite the sixth tooth of the median row or alternate between the sixth and seventh of the left internal lateral row.

All teeth are normal except the fifth, which is considerably smaller than the rest of the teeth in this row. It approaches in size the most anterior or the eighth tooth of the left internal row.

The prevomer has been crushed out of position and lies in front of the skull. Firmly attached to the prevomer is the parasphenoid. It extends posteriorly 29.7 mm. from the last tooth in the median row. There is no evidence that the parasphenoid is attached to the prevomer as in *Coelodus*, a conclusion based on the study of the

prevomer in *C. streckeri*, for in this latter form a concavity is present at the posterior base of the prevomer, into which the parasphenoid apparently fits.

The anterior roofing bones of the skull are covered by a layer of ganoin, bearing numerous conical granulations ending in blunt points. There are no pits on the covering of the bones except where the granulations have been broken. These granulations are hollow at the base. The circular base is a ring of enamel. The removal of the ganoin covering reveals the suture between the frontals and dermethmoid (see fig. 1). The portion of the crushed frontals gives the following measurements: left 25 mm. in length, width at midline, 12 mm.; right 23.7 mm. in length, width at midline, 14 mm. The suture separating the anterior part of the frontals from the dermethmoid is very irregular. Nasals and premaxillaries are lacking. The left orbital ring seems to be represented in part.

*Discussion.* *Pycnomicrodon kansasensis* is distinguished from other known genera of the family *Pycnodontidae*, by its smooth rhomboidal scales and five rows of small, smooth, noncrenulated, closely set prevomerine teeth.

It is impossible to compare it with genera based wholly upon splenial dentition, though in no case is there a splenial dentition known to be small enough to be associated with this form.

## PLATE I

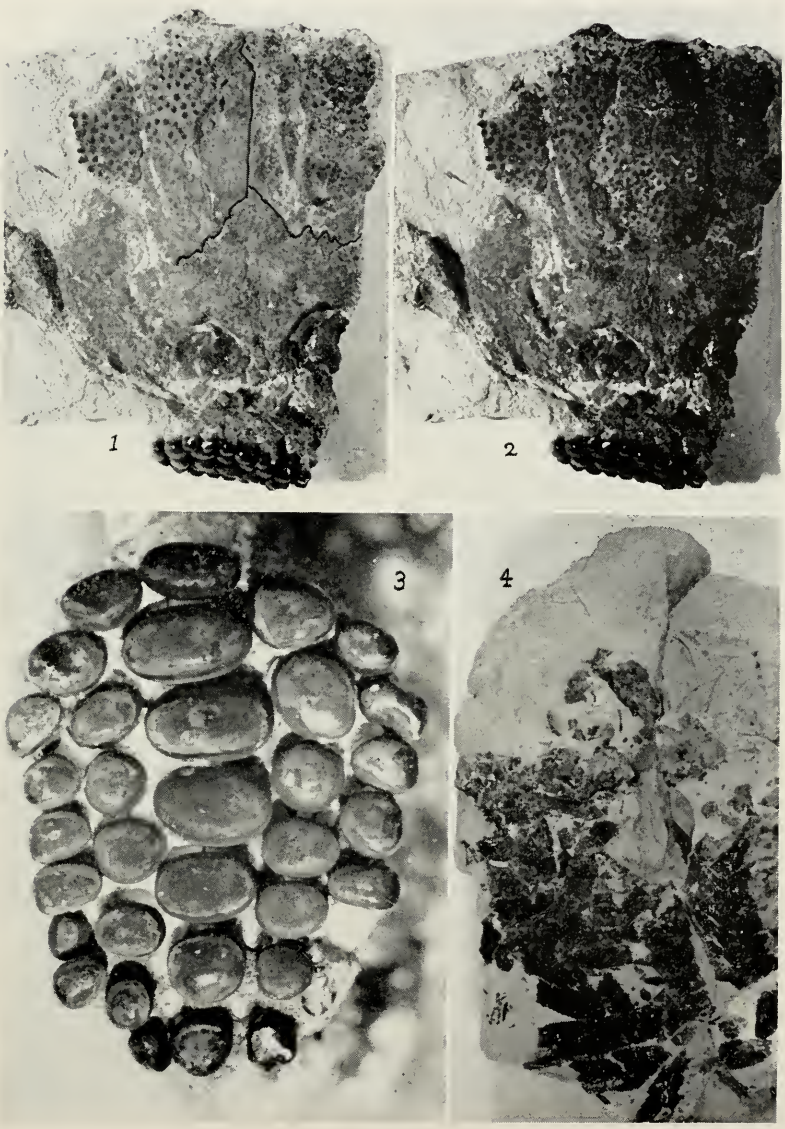
FIG. 1. *Pycnomicrodon kansasensis* Hibbard and Graffham, type, anterior part of skull with dermal covering removed showing suture between frontals and dermethmoid, No. 1019F, × 1$^{3}/_{17}$.

FIG. 2. *Pycnomicrodon kansasensis,* anterior part of skull with prevomer, No. 1019F. ×1$^{3}/_{17}$.

FIG. 3. *Pycnomicrodon kansasensis,* prevomer with dental series, No. 1019F, × 3$^{13}/_{17}$.

FIG. 4. *Pycnomicrodon kansasensis,* opercular region, No. 1019F, × ½.

PLATE I



THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XXVII] NOVEMBER 1, 1941 [No. 6

# Paleoecology and Correlation of the Rexroad Fauna from the Upper Pliocene of Southwestern Kansas, as Indicated by the Mammals [1]

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ABSTRACT: Field technique used for the recovery of small fossils by the Kansas University Museum of Vertebrate Paleontology is described. A measured section is given of one of the best-known exposures of the Upper Pliocene in western Kansas. The age of the Rexroad fauna is discussed, and a comparison is made with other known Upper Pliocene faunas of North America. A list of the mollusks found associated with the vertebrate fauna is given as identified by F. C. Baker, also a list of the Rexroad mammals, which comprises 8 orders, 37 genera and 32 identified species. The true Rexroad fauna shows relationships with forms now found in southwestern United States, Mexico and Central America rather than with Recent forms now found in southwestern Kansas. A discussion is given on the paleoecology of that time. The fauna indicates that meadow flats and timbered areas existed at least along portions of the Upper Pliocene stream valley, and that the climatic conditions then were not drier nor colder than at present. Moreover, there is some indication that climate in the Upper Pliocene was more equable than at present, without extremely cold winters or severely hot summers, and that there was a somewhat greater degree of humidity.

## INTRODUCTION

THE Tertiary faunas of the Great Plains are inadequately known, and the smaller vertebrates especially have many times been overlooked. The reconstruction of the past mammalian life has until recently been based almost entirely on the larger and more conspicuous forms. Only occasionally have the remains of the smaller mammals been taken in association with the larger species. In fact, it was believed for years that the remains of the smaller vertebrates were mostly missing from the deposits. The demand for spectacular

1. A condensation of a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the University of Michigan.

exhibits has led each field party to search for larger and better specimens, constantly overlooking, without a doubt, deposits containing small vertebrates. The practice of excavating with plow and scraper, followed by pick and shovel, to remove the greater part of the matrix around the larger bones probably has destroyed more vertebrate remains than have ever been recovered. My experience in collecting fossils has convinced me that almost any deposit that yields the bones of large mammals contains also the bones of the smaller forms. It seemed evident that a careful search of the deposits would yield a nearly complete fauna, adding much to the knowledge of its distribution through time and space, and its phylogeny, as well as helping to interpret the environmental conditions under which many of the forms lived.

The discovery of the Upper Pliocene deposits in southwestern Kansas led to intensified work in that area because the fauna was new and unknown for that part of the High Plains. Every effort is being made to recover as complete a fauna as possible. The fauna here described is noteworthy among Upper Pliocene faunas since it is the largest known in North America. The investigation of this fauna has involved the study of other known Upper Pliocene faunas and deposits, and careful comparisons have been made with them as well as with Pleistocene and Recent forms.

The small mammals, as a rule, furnish more knowledge of the past environment at the time when they lived than do the larger forms, since the former are generally confined to more specific ecological niches than the latter. The large number of small forms recovered in this area has made possible the reconstruction of past ecological conditions in a manner hitherto impossible because of insufficient material.

The attempted reconstruction here of the ecological conditions prevailing in southwestern Kansas in the Upper Pliocene has been based primarily on the adaptive characters exhibited by the animals and on the geological evidence shown by stratigraphic position and nature of the deposits. This reconstruction has been greatly facilitated by the deductions made possible by having this large fauna of small mammals available for study and by the comparison with the ecology of the present mammalian fauna.

## ACKNOWLEDGMENTS

I am greatly indebted to Dr. Lee R. Dice, Dr. E. C. Case, Dr. W. H. Burt, and Dr. Carl L. Hubbs of the University of Michigan, and Dr. H. H. Lane of the University of Kansas, for advice and criticism during the preparation of this paper; and to Dr. John C. Frye of the United States Geological Survey and Dr. H. T. U. Smith of the University of Kansas, for their advice, which they have freely given me concerning the geology of Meade county and the surrounding area. The drawing was made by Miss Frances Watson.

## FIELD OPERATIONS

While working in Meade county the past five summers (1936-'40), a number of exposures have been located that have yielded fossil vertebrates. These exposures have been numbered in the order in which they were located. The exact locations are not here published, but will appear after our work has been completed. Only three Upper Pliocene exposures have been found which contain fossils. These exposures are known as Localities Nos. 1, 2 and 3, and will be referred to as such in this paper. These three localities are situated in a nearly due north-and-south direction from one another within a distance of three-fourths of a mile along side branches of a tributary stream of Crooked creek, each locality being separated from the others by a narrow divide covered with Pleistocene and Recent deposits.

The fossil remains in the Upper Pliocene deposit of Meade county, Kansas, were first found by CCC workmen who removed them for souvenirs. Dr. M. K. Elias, in the spring of 1936, visited one of the quarries in Meade county, Kansas, where consolidated sand was being removed to be used as riprap on a state lake project. While there, he inquired about the presence of fossil bones and was presented with isolated teeth which had been removed from deposits below the stone quarries. Upon his return to the University of Kansas, the specimens were given to the Museum of Vertebrate Paleontology and the deposit was reported with the information given that considerable material had been removed, chiefly isolated horse teeth, and a number of mastodon teeth.

Upon our arrival in Meade county in the summer of 1936, it was found that the entire deposit so far as was known at that time had been worked by men from a CCC camp. The men had uncovered parts of five mastodon skeletons, including a number of tusks, lower jaws, and parts of skulls, at the locality now known as No. 3. The

exposed material was then swept away by a cloudburst, and the only trace of fossils left was a few bits of ivory scattered along the stream bed. It was reported that one small deposit of sand, now known as Locality No. 2, had yielded many teeth and small lower jaws, but these had been scattered and only a few isolated horse teeth were located. The teeth had been divided among the workers, who would not part with them. This locality was visited and found to have been exhausted, but the careful sifting of the CCC dump at this locality, and the sifting of another dump one-half mile north, known as Locality No. 1, yielded the fauna described by Hibbard (1938) as the "Rexroad fauna," after the name of the ranch on which it was collected. The siftings yielded a greater small vertebrate fauna from these two localities than had previously been recovered by the use of the team and scraper during a number of years' collecting in Kansas. Encouraged by this, our work has since been chiefly confined to the recovery of the small vertebrate fauna from the Upper Pliocene deposit in southwestern Kansas.

The CCC camp was abandoned by the spring of 1937, and thereafter we could proceed undisturbed with our investigations. The summer of 1937 was spent looking for favorable outcrops, and the removal of small fossils. One week was spent reworking Localities Nos. 1 and 2. Work was then started on Locality No. 3, which is one-fourth mile south of Locality No. 2. Here a few small bones were exposed in some lenses of fine sand within sandy silt. The sand was removed with awls. The bones when exposed were very fragile because of the moisture content. As soon as a small shovel full of sand was removed, it was placed on a towel to dry. When the sand was thoroughly dry we began the slow process of looking over the material for fossils and their removal from the sand with a pair of tweezers. Then the sand was carefully put through a sieve. The contents left in the sieve were again looked over, while that which went through the sieve was carefully examined. Our recovery of material was nearly one hundred percent of what was contained in the removed matrix, excepting the small isolated teeth of shrews. Six weeks were spent at Locality No. 3 removing approximately three cubic yards of dirt.

The following summer, 1938, we returned to Locality No. 3 and proceeded as in the summer before. Soon after beginning our work we discovered a few bone fragments in the clay deposit at Locality No. 2. We worked for one week devising a method of recovering the small fossils from the clay since it was impossible to dig them out.

Clods of dry clay were taken to a stream and placed in the water, where they rapidly disintegrated and the small bones dropped free from the clay particles. At once we began working on a washing device and soon had one perfected which would handle one-half shovel of dry clay. Four of these devices were made. Clay was removed from the deposits and hauled to the stream, where it was put through the washers and the remains placed on towels to dry in the sun. The recovery of specimens from clay is slower than that from the fine sand or sandy silt due to the time required for washing and drying. The fossils taken from the clay are badly broken, due to the cracks in the clay, which produced a large amount of useless fragmentary material. By this method of recovery, from one to five lower jaws were taken in a day with perfect drying conditions. It is impossible to wash specimens from wet or damp clay. Neither the sifting of quarried material nor the washing of fossils from the matrix are new field methods, but have been used by Brown (1908, p. 162) and Loomis (1926, p. 7).

The summer of 1939 also was spent working Locality No. 2 and Locality No. 3. The material recovered from Localities Nos. 1, 2, and 3 forms the basis of this paper. The fragmentary material indicates the presence of large forms though only a few bones and teeth have been found while removing the small amount of matrix. It has been deemed unwise to destroy the small material in an effort to recover larger forms. As soon as a nearly complete small fauna has been recovered with a good representative collection of individuals, the old method of "gutting" the locality will be used in an attempt to recover the remains of the larger forms.

## GEOLOGY OF THE UPPER PLIOCENE BEDS

The geology of this area is being studied by Dr. H. T. U. Smith (1940) and by Dr. John C. Frye (1940 and MS). All references to any phase of the geology of the area are from papers in press, manuscripts, or from oral communication with the authors.

So far as is known, from our field work in Meade county, the exposed Upper Pliocene deposits occur as isolated patches to the west of Crooked creek in an area two miles wide and twelve miles long, where they crop out along the stream beds of east-flowing tributaries of Crooked creek. They are exposed only where the present streams have cut through the overlying Pleistocene deposits, leaving them exposed in the stream bed or where the streams by lateral planation have produced steep cut banks. The beds dip from the high plains on the west toward the present valley of Crooked creek,

at approximately 36 feet per mile, and are on the downthrow side of the most important of several faults, according to Frye (MS).

In most places where the Upper Pliocene deposits underlie the surface they are quite nonresistant to erosion, and produce a topography which slopes gently toward the southeast. Generally the lower slopes of the tributary valleys on the west side of Crooked creek are covered by grass and yucca or sage brush, hiding most of the deposit. The shallow overlying Pleistocene and Recent sediment hides the Upper Pliocene deposits where they pass under the high plains to the west. The exposed Upper Pliocene deposits studied consist of sand, sandy silt, clay and bog material. Some of the beds of sand are cemented with calcium carbonate. Below is given one of the more complete sections of the Upper Pliocene exposed in Meade county. This section was measured by Frye and Hibbard, in the "Deer Park" in Meade County State Park, fourteen miles south-southwest of Meade, Kansas.

| | | *Feet* |
|---|---|---|
| 1. | Surface soil | 0.2 |
| 2. | "Mortar" bed—cemented conglomerate, containing granite and caliche pebbles, and pebbles and cobbles of clay resembling the underlying beds, cross bedded. A few beds show a black stain of manganese. (Pleistocene.) | 10.0 |
| 3. | Erosional unconformity | —— |
| 4. | Sand, fine, and silt, gray and tan, mottled and streaked; loosely cemented. Thin bedded, but bedding does not weather out. (Top of Upper Pliocene beds.) | 2.0 |
| 5. | Clay and silt, gray and tan, brown at top. Tough when dry. (Rexroad fauna.) | 3.4 |
| 6. | Sand with some silt and clay, light pink-tan, massive, fairly loose, contains a small amount of caliche | 5.4 |
| 7. | Clay, silt and sand, red-brown and gray, with caliche nodules. Becomes more calcareous upward | 2.0 |
| 8. | Sand with some gravel, tan, loose, with a few cemented beds, partly covered | 17.8 |
| | | 40.8 |

The fauna discussed in this paper was taken from clay, sandy silt, fine sand included in lenses in the silt, and from bog material, at the three isolated exposures previously mentioned. No fossils have been recovered in place from the thick cross-bedded channel sands. The fossils coming from the bog material are poorly preserved, and to date only teeth have been recovered from it in good condition. Bones in the bog material are represented only by a fine reddish-brown powder. The bones taken from the clay are stained a reddish-brown and are more fragile than those taken from the sandy silt and the lenses of fine sand in the silt. The specimens taken from the lenses of fine sand within the sandy silt, and from the sandy silt itself are nearly white in appearance, and are very soft when moist, but become hard when dry.

TEXT FIG. 1. Outline map of western United States showing location of the principal Upper Pliocene vertebrate localities.

## AGE AND RELATIONSHIPS OF THE REXROAD FAUNA

Continental deposits of the Upper Pliocene are poorly known in North America. A number of scattered localities have yielded fragmentary fossils indicating an Upper Pliocene age, though only three deposits have yielded large enough mammalian faunas to be useful in a careful study of comparative ages within the Upper Pliocene. The first discovered deposit of Upper Pliocene age in North America was that of the Blanco beds in Crosby county, Texas, which was reported by Cummins (1890). In his report Cummins gave two sections measured near Mount Blanco, Texas. He named the beds the "Blanco Canyon Beds" and did not attempt to determine their exact geological age because of insufficient data. Cummins collected some vertebrates from his horizon No. 5 (Packsand) which were sent

to Cope for identification. Cope (1892) published on the fragmentary remains. Because of the interesting fauna he then accompanied Cummins in the field to make a better collection of vertebrates. Cope (1893) then published an account of the entire vertebrate fauna. It was, however, not until Gidley (1903) published his report on the work at Mount Blanco that the distribution and position of the Blanco beds in Cummins' sections were clearly understood. Gidley pointed out that Cummins' two sections, measured near Mount Blanco, contained both Blanco beds and older Tertiary material. Gidley restricted the name "Blanco beds" to those of Upper Pliocene age only and from his work in the area drew the following conclusions: (1) "The fossil-bearing formations are fluviatile, not lacustrine in origin," (2) "The Blanco has a limited distribution."

Following is a list of fossil mammals known from the Blanco fauna:

Edentata:
*Megalonyx leptostomus* Cope.
*Glyptotherium texanum* Osborn.
Carnivora:
*Borophagus diversidens* Cope.
*Osteoborus hillanus* (Cope).
*Canimartes cumminsii* Cope.
Proboscidea:
*Serbelodon* (?) *praecursor* (Cope).
*Rhynchotherium falconeri* Osborn.
*Stegomastodon successor* (Cope).
*Stegomastodon texanus* Osborn.
Perissodactyla:
*Plesippus simplicidens* (Cope).
*Plesippus cumminsii* (Cope).
*Nannippus phlegon* (Hay).
Artiodactyla:
*Platygonus bicalcaratus* Cope.
*Platygonus texanus* Gidley.
*Pliauchenia spatula* Cope.

Johnston (1937, 1938) and Stirton and Christian (1940) have made preliminary reports on the Cita Canyon fauna of Randall county, Texas. Johnston (1938) calls attention to "an assemblage of animals related to the Mount Blanco fauna on the one hand and the Lower Pleistocene of Rock creek on the other." The fauna is Upper Pliocene in age and its exact relationship to the Blanco fauna awaits the publication of Johnston's manuscript, which has been greatly delayed because of his untimely death. The Cita Canyon fauna is considerably larger than the Blanco and will help greatly in giving a clearer picture of the Upper Pliocene faunas of the high plains region.

The second Upper Pliocene fauna to be reported was the Pittsburg of California by Merriam (1903). Since that time a number of localities in California have yielded a few specimens of Upper Plio-

cene age, such as the Tehama, San Timoteo, and Coso Mountains faunas.

Following is a composite list of Upper Pliocene mammalian faunas from California:

Edentata:
*Megalonyx* (?) sp.
Carnivora:
*Borophagus pachyodon* (Merriam).
*Borophagus solus* (Stock).
*Canis* sp.
Rodentia:
*Cosomys primus* Wilson.
Lagomorpha:
*Hypolagus* cf. *limnetus* Gazin.
Proboscidea:
*Pliomastodon* (?) *cosoensis* Schultz.
*Stegomastodon* cf. *arizonae* Gidley.
Perissodactyla:
*Plesippus proversus* (Merriam).
*Plesippus francescana* (Frick).
Artiodactyla:
*Platygonus* sp.
Camelid sp.
*Antilocapra*? sp.
*Odocoileus*? sp.

Gidley (1922) described a rodent fauna from the Upper Pliocene of Arizona which is known as the Benson fauna. This is one of the best known small vertebrate faunas of the Upper Pliocene of North America. A few years later, Gidley (1930) published upon another Upper Pliocene fauna from Idaho, known as the Hagerman fauna. At present this is the most completely known mammalian fauna from the Upper Pliocene of North America.

Following is a list of the fossil mammals known from the Hagerman fauna:*

Edentata:
*Megalonyx leptonyx*? (Marsh).
Insectivora:
*Blarina gidleyi* Gazin.
Carnivora:
Canid sp.
*Hyaenognathus* or *Borophagus* sp.
*Canimartes*? *idahoensis* (Gazin).
*Canimartes*? *cookii* (Gazin).
*Lutra* (*Satherium*) *priscinaria* Leidy.
*Felis lacustris* Gazin.
*Machairodus*? *hesperus* Gazin.
Rodentia:
Citellid sp.
Marmot sp.
*Castor accessor*? Hay.
*Thomomys gidleyi* Wilson.
*Cosomys primus* Wilson.
*Pliopotamps idahoensis minor* (Wilson).
Lagomorpha:
*Hypolagus* near *vetus* (Kellogg).
*Hypolagus limnetus* Gazin.
*Alilepus*? *vagus* Gazin.
Proboscidea:
Mastodont.
Perissodactyla:
*Plesippus shoshonensis* Gidley.
Artiodactyla:
*Platygonus pearcei* Gazin.
Camelid, cf. *Camelops arenarum* Hay.
Camelid, cf. *Procamelus* or *Tanupolama*.
Cervid sp.
*Ceratomeryx prenticei* Gazin

* The Hagerman faunal list is essentially that given by Gazin (1936) with slight changes in nomenclature.

Following is a list of the fossil mammals known from the Benson fauna:

Carnivora:
- Canid sp.
- Mustelid sp.

Rodentia:
- *Citellus bensoni* Gidley.
- *Geomys minor* Gidley.
- *Cratogeomys bensoni* Gidley.
- *Cupidinimus magnus* (Kellogg).
- *Dipodomys minor* Gidley.
- *Onychomys bensoni* Gidley.
- *Baiomys minimus* (Gidley).
- *Eligmodontia? arizonae* Gidley.
- *Sigmodon medius* Gidley.
- *Neotoma fossilis* Gidley.

Lagomorpha:
- *Hypolagus* small sp.
- *Hypolagus*? large sp.

Proboscidea:
- *Cordillerion bensonensis* Gidley.

Perissodactyla:
- *Pliohippus*? sp.
- *Nannippus phlegon* (Hay).

Artiodactyla:
- *Platygonus* sp.
- *Procamelus*? sp.
- *Pliauchenia*? sp.
- *Meryeodus*? sp.

The determination of the age of the Rexroad fauna as Upper Pliocene was based by Hibbard (1938) on the presence of *Equus* cf. *simplicidens* Cope, *Equus* cf. *cumminsii* Cope and *Nannippus phlegon* (Hay), as identified by Dr. R. A. Stirton, the absence of rhinoceros remains, which are abundant in the Middle Pliocene of Kansas, increase in the abundance of fragmentary remains of the early mastodonts, and total absence of true Pleistocene forms, *e. g., Paramylodon, Smilodon, Castoroides, Lepus, Sylvilagus, Equus excelsus* and *E. niobrarensis,* mammoths, and bison.

Following is a list of the fossil mammals known from the Rexroad fauna:

Insectivora:
- *Sorex taylori* Hibbard.
- *Blarina*? sp.
- *Hesperoscalops rexroadi* Hibbard.
- *Scalopus* sp.

Chiroptera:
- genus?

Carnivora:
- *Canis lepophagus* Johnston.
- *Canis large* sp.
- *Procyon rexroadensis* Hibbard.
- *Brachyprotoma breviramus* Hibbard.
- *Spilogale rexroadi* Hibbard.
- *Taxidea taxus* (Schreber).
- *Trigonictis kansasensis* Hibbard.
- *Machairodus* sp.
- *Felis* large sp.
- *Felis lacustris* Gazin.

Rodentia:
- *Citellus howelli* Hibbard.
- *Citellus rexroadensis* Hibbard.
- *Eutamias* or *Tamias* sp.
- *Geomys* sp.
- *Liomys centralis* Hibbard.
- *Perognathus gidleyi* Hibbard.
- *Procastoroides lanei* (Hibbard).
- *Onychomys* sp.
- *Baiomys rexroadi* Hibbard.
- *Peromyscus kansasensis* Hibbard.
- *Eligmodontia? arizonae* Gidley.
- *Symmetrodontomys simplicidens* Hibbard.
- *Sigmodon intermedius* Hibbard.
- *Parahodomys quadriplicatus* Hibbard.

*Pliolemmus antiquus* Hibbard.
*Phenacomys primaevus* Hibbard.
*Ogmodontomys poaphagus* Hibbard.
*Pliopotamys meadensis* Hibbard.
Lagomorpha:
*Pratilepus kansasensis* Hibbard.
*Dicea lepuscula* Hibbard.
*Nekrolagus progressus* (Hibbard).
*Hypolagus regalis* Hibbard.
Proboscidea:
Mastodont sp.
Perissodactyla:
*Plesippus simplicidens* (Cope).
*Nannippus phlegon* (Hay).
Artiodactyla:
*Platygonus* sp.
Camelid small sp.
Camelid large sp.
Cervid sp.
*Capromeryx*? sp.

*Correlation of the fauna.* The absence of edentates from the Rexroad fauna cannot be taken as evidence that they did not make up a part of that fauna. Their apparent absence is probably due to inadequate collecting of the larger forms.

The insectivores of the Rexroad fauna provide no correlation with the other Upper Pliocene faunas because of the scarcity of insectivores in other collections. *Scalopus* has been reported from the earlier Pliocene of Nebraska by Matthew (1924) and is known from the Pleistocene and Recent.

A number of carnivores are known from the Blanco, Hagerman and Rexroad faunas, but only a few forms are sufficiently well known to be used in correlation. Carnivores, as a rule, enjoyed a wide geographical distribution, and not until the vertical range of a species is known can it be depended upon for an accurate horizontal correlation; therefore, generalizations can be made only from the knowledge of other fossil and recent forms. *Canis lepophagus* occurs both in the Cita Canyon and the Rexroad faunas. *Felis lacustris* occurs both in the Hagerman and the Rexroad faunas. We may safely assume that both of these forms ranged as widely during the Upper Pliocene as *Canis latrans* and *Felis concolor* do today. On the basis of these two fossil forms the three faunas appear to be of approximately the same age, if we disregard the vertical range of the fossil species, which is not known at present. From our knowledge of the remaining carnivores there is at present nothing in common between the Upper Pliocene faunas unless *Trigonictis* from the Rexroad fauna and *Canimartes*? from the Hagerman fauna are generically the same. A clear understanding of the taxonomic position of these two forms depends upon more adequate material. It is interesting to note that *Brachyprotoma,* an extinct Pleistocene genus, occurs in the Rexroad, and *Spilogale* is represented by a distinct species. From a study of the material at hand, it appears that

the *Taxidea* show no change from Upper Pliocene to the present time.

The rodents, as a whole, show a greater plasticity than the other groups of mammals, and, therefore, may be considered as better indicators of environmental conditions. Compared with carnivores, the geographical range of a given rodent species is more limited, and consequently we may expect a greater difference between faunas separated by differences in latitude and altitude and especially when separated by both latitude and altitude. A rodent fauna has never been collected from the Blanco or Cita Canyon beds of Texas, but rodents are present in these deposits and especially in the Cita Canyon, where a number of fragmentary bones were observed in the summer of 1939. The collecting methods in these deposits should be revised if small material is to be recovered. If the Blanco and Cita Canyon beds are the same age as the Benson, a rodent fauna from them should be more nearly identical with the Benson than with that of any of the other well-known Upper Pliocene faunas because of the close geographical relation of the three deposits and only a slight difference in altitude. The Rexroad fauna, if the same age as the other Upper Pliocene faunas, should show a closer relationship with the Cita Canyon and Blanco faunas than with the Benson fauna, but a closer relationship with the Benson than with the Hagerman fauna. These suppositions are based upon the geographical relation of the faunas.

*Citellus* is known from most of the Upper Pliocene faunas. The differences between the Benson and Rexroad forms are no greater than the differences between the present citellids of the respective regions.

*Geomys* occurred in both the Rexroad and Benson faunas, and occurs in the present fauna of western Kansas. *Thomomys* is known from the Hagerman and *Cratogeomys* from the Benson. To date *Cratogeomys* is not known to occur in Kansas earlier than the Recent.

The heteromyids are best known from the Benson, and at present furnish no evidence for correlation between faunas, due to the absence of sufficient material from the other faunas.

The following genera of the cricetid rodents are common to the Benson and Rexroad: *Onychomys, Baiomys, Eligmodontia*? and *Sigmodon*. The abundance of these forms is about the same in both faunas, *Sigmodon* being far more abundant than the other genera in both deposits. The species of *Eligmodontia,* reported by Gidley

from the Benson, does not belong to that genus as known today, though the specimen has many characters in common with the Central and South American genera *Akodon* and *Eligmodontia*, and with *Symmetrodontomys* from the Rexroad, which it closely resembles.

The genus *Eligmodontia?* or *Symmetrodontomys* could not have given rise to *Peromyscus* and shows no close relationship to it, nor to *Reithrodontomys*, *Onychomys* or *Oryzomys*. Regardless of the fact that Hibbard (1939b) referred (with question) a form from the Middle Pliocene of Kansas to the genus *Oryzomys*, the fossil evidence at hand today indicates that *Reithrodontomys* and *Oryzomys* made its appearance in Central North America about the same time as the subgenus *Peromyscus;* that is, approximately middle to late Pleistocene time.

Voles and lemmings are not known from the Benson fauna. This may be due in part to the geographical position of the deposit. They are well represented in the Rexroad, both by genera and individuals. In this respect, the fauna shows a close relationship to the Hagerman.

Because of the geographical position of the Rexroad fauna one would expect to find it an intermediate fauna between the Benson and Hagerman if they were all of the same age; this opinion is based upon knowledge of the recent mammals of these areas. The Hagerman fauna is considered to represent a northern fauna and the Benson fauna a southern fauna because of their geographical position. The Rexroad seems to include the more tolerant species from both the northern and southern areas. The presence of *Pliopotamys* indicates a close age relationship between the Hagerman and the Rexroad faunas.

*Pliolemmus antiquus, Phenacomys primaevus,* and *Pliopotamys meadensis* may be forms that appeared late in the Rexroad fauna, since they have never been recovered from Locality No. 3; nor from the clays of No. 2 that have produced a fauna identical with No. 3. The variation in *Procastoroides* was previously pointed out. I do not believe that more than one species of the beaver was established in the Rexroad fauna at any one time. The size variation of the teeth is greater than individual or age variation. Therefore, it may represent a changing beaver fauna; if so, it will not be clearly understood until more material is available. It is well to point out again the type of deposits at the three localities. Locality No. 1 is well covered by slump and rewashed materials from the higher surrounding areas. The fossils taken from this quarry were largely

recovered by sifting the diggings of the CCC camp. At this locality, there is, resting unconformably upon the Upper Pliocene clay, Pleistocene sand and gravel, and reworked lime nodules from the higher outcrops of the Upper Pliocene. This rubble and top soil ranges from one foot to nearly three feet in depth. From the reworked lime nodules and fine sand were recovered a large number of reworked Upper Pliocene horse teeth, mastodont teeth, and camel teeth. The small rodent material showed no signs of being redeposited, though there is a possibility that some of it could have come from the reworked material as well as from the underlying clays, since it was sifted from the dumps. At Locality No. 2, a sand pocket was found in the clay. This pocket, though exposed at the surface, was completely surrounded by clay, which was in place, and not slumped into its present position. The pocket was approximately three feet in diameter and ten feet deep, leading directly into a bed of sand below the clay which is definitely a part of the Upper Pliocene. *Pliolemmus, Phenacomys* and *Pliopotamys* were recovered only from this sand pocket, and never from the clays at this quarry. This sand pocket produced horse teeth identical with those taken from the clay deposits at No. 2 and No. 3. The exposed bank of sandy clay at No. 2 is unconformably overlain by a Pleistocene gravel, and the material coming from the clay was definitely in place. The No. 3 exposure presents no possibility of a mixed fauna of younger age as it is a sheer cut with the Upper Pliocene deposit exposed at the base and overlain near the top by Pleistocene gravel. There is the possibility that these forms represented rare individuals within the fauna or forms just beginning to occur because of the extension of their ranges.

The rabbits have to date been of but little help in the determination of the age of the fauna. *Hypolagus* occurs in the Benson, Hagerman and Rexroad faunas; because of its range from Lower Pliocene to Pleistocene and its poorly known species it does not afford a basis for correlation. The other genera are distinct and have closer relationships with the earlier Pliocene rabbits than the Pleistocene forms.

Horses are well known from the Blanco, Hagerman, and Rexroad, and, in part, from the Benson. At present the great difficulty in using the horse for time correlation is that its vertical range is not known. On the basis of the presence of *Nannippus phlegon,* the Blanco, Benson and Rexroad seem to be more closely related to one another than they are to the Hagerman, unless *Nannippus* is a

southwestern form. On the basis of the horse material the age of the Rexroad, Blanco and Benson are the same.

The artiodactyles are not well enough known from the Rexroad to be used in correlation in age.

The Hagerman consists of what is considered as a northern fauna and the Benson a southern fauna. The Rexroad fauna possesses what is considered as both northern and southern elements. On the basis of the fossil evidence at hand, the Rexroad, Blanco, Benson, and the Hagerman faunas are of the same approximate age, if one considers all the mammals of the Rexroad fauna as contemporaneous. The difference between the faunas is accounted for apparently by the geographical positions of the faunas. However, if it should be proven in the future by additional material that *Pliopotamys*, *Pliolemmus* and *Phenacomys* represent a part of a younger fauna, this would indicate that the Hagerman fauna is probably slightly younger than the Rexroad fauna. The difference between the Blanco and Hagerman faunas was considered by Gazin (1936) as probably being only of geographic significance. The present elevations of the areas from which the faunas were taken are not noticeably different from one another, ranging approximately from 2,500 to 3,600 feet. The Benson fauna is situated at approximately latitude 31° 30′ N., Blanco approximately 33° 30′ N., Rexroad approximately 37° N., and the Hagerman 42° 30′ N.

Because of the uncertainty of the correlations of faunas in North America, it seems unwise at the present to attempt a correlation with European or Asiatic faunas. Much has been written on the subject, but no forms that were found in the Rexroad fauna will afford any better material for correlation than those previously known. Pilgrim (1940) in one of the latest papers on correlation brings out a number of points for consideration in correlation. One of the best is his statement, "It cannot, however, be denied that the nearer we approach to recent times, the slower is the rate of change." This has been observed by most students of the vertebrates in all of the classes except the mammals and when more thought is given to this and to the fact that the occurrence of like forms in widely separated areas cannot be considered as an indication of synchronous time, more accurate correlations will be attempted.

## PALEOECOLOGY OF THE REXROAD FAUNA

Paleoecology is a division of paleontology that has remained nearly untouched. This is due in part to the lack of many essential data, and in part to the fact that anyone attempting to reconstruct past conditions upon scanty evidence hesitates because of the danger of the misinterpretation of the material if it does not come from a trapped deposit such as a cave, tar pit, etc. Studies of the floras, the invertebrate and vertebrate faunas, stratigraphy, physiography, palaeogeography, and the climatology have rarely been made for any given deposit. Paleontologists have seldom been able to find floras and faunas sufficiently well associated in a given deposit to furnish a sound basis for the description of the environment at the time the deposit was laid down.

The best guide for anyone attempting to work in the field of vertebrate paleoecology is given by Case (1919) in "The Environment of Vertebrate Life in the Late Paleozoic in North America; a Paleographic Study," which resulted from a number of years of work in the field of paleontology. Further help in attacking a study of paleoecology is Barrell's (1908) paper on, "Relations between Climate and Terrestrial Deposits," and the two reports of the Committee on Paleoecology (Twenhofel, chairman, 1936 and 1937). Clements (1918) discussed the "Scope and Significance of Paleoecology," based on paleobotany, in which he points out many factors to be observed in such a study. Chaney has contributed more to paleoecology of floras of the Tertiary than any other worker in North America. His papers are very useful in the study of climatic conditions in the Tertiary, and provide a starting point in a study of certain mammalian faunas of that age.

In attempting a discussion of the paleoecology of the Rexroad mammalian fauna, we must assume that climate controls the development of the vegetation and that climate and vegetation control directly or indirectly the animal life. Also the following facts must be considered; first, that known fossil faunas usually consist of only a few individuals of a given species. Therefore, it is not always possible to distinguish between rare and common species in a fauna. Second, there is always the possibility of redeposition of slightly older forms with a recent fauna, or vice versa, and the forms found together in stream deposits may represent a mixture of all that occurred in every part of the drainage system of the stream. One cannot assume that the fossils taken from a stream deposit belong to a

local fauna. The larger the stream that laid down the deposit, the greater the chance that some of the fossils are from widely separated areas.

From a study of the few exposed deposits, it seems that the Meade area in Upper Pliocene time presented a rolling surface with a wide river valley bordered by low rolling hills covered with vegetation. The low gradient stream is considered to have been mountain-fed and to have flowed in a southward direction toward the Gulf of Mexico. The climatic conditions must be reconstructed from the characters of the fauna.

A knowledge of the fossil flora of this area would help one to interpret both the climate and the fauna, but this information is entirely lacking because no plant remains could be identified.

Associated with the mammals of the Rexroad fauna were the following mollusks which were identified by Dr. F. C. Baker.

Fresh-water shells:
- *Pisidium* sp.
- *Stagnicola reflexa* (Say).
- *Physa anatina* Lea.
- *Ferrissia rivularis* (Say).
- *Ferrissia parallela* (Haldeman).
- *Menetus kansasensis* F. C. Baker.

Land snails:
- *Carychium perexiguum* F. C. Baker.
- *Polygyra mooreana tholus* (Binney).
- *Retinella electrina* (Gould).
- *Retinella* rhoadsi Pilsbry.
- *Retinella wheatleyi* Bland.
- *Hawaii miniscula* Binney.
- *Helicodiscus singleyanus* Pilsbry.
- *Gastrocopta tappaniana* C. B. Adams.
- *Gastrocopta holzingeri* (Sterki).
- *Gastrocopta cristata* Pilsbry and Vanatta.
- *Vertigo hibbardi* F. C. Baker.
- *Vertigo milium* Gould.
- *Pupoides marginatus* (Say).
- *Pupoides inornatus* Vanatta.
- *Strobilops sparsicostata* F. C. Baker.
- *Vallonia gracilicosta* Reinhardt.
- *Succinea grosvenori* Lea.
- *Succinea grosvenori gelida* F. C. Baker.

Doctor Baker wrote in a letter dated January 29, 1940, "The ecology of this deposit appears to have been a river or slough, judged by the character of the fresh-water fauna. The land species lived in well-wooded situations and were probably washed into the fresh-water bodies during rains, from the hillsides. The great abundance of species indicates that at this time the mollusk fauna was well developed. I would say the climate was warm."

The remains of fishes are chiefly spines of catfish, which will be studied in the near future. Apparently the presence of catfish would indicate a stream with more or less permanent pools of water having partially silted bottoms or oxbow lakes along the stream valley.

The amphibian fauna has not been identified, though Doctor Taylor says, "It consists of the remains of salamanders, frogs and toads,

representing an amphibian fauna larger than the present amphibian fauna of Meade county, with a decided increase in the number of species of frogs." This would indicate a more humid condition than exists at the present time in the area.

The fragmentary reptile material indicates a lizard and snake fauna comparable in number with the present-day fauna, but at present this material does not throw any light on past ecological conditions.

The fossil bird material has not been identified, therefore it is impossible as yet to use the material in an ecological study.

The mammalian fauna is represented by 8 orders, 37 identified genera and 32 identified species. This is a larger mammalian fauna than is known to have occurred in the area in Recent time, provided the fossil forms represent an associated fauna that lived together in that area during the Upper Pliocene and not an assemblage of forms some of which represent in part faunas of a different age or forms washed in from areas far upstream. The small forms show no signs of having been reworked or having been carried a great distance before deposition, though to date no complete skeletons have been found associated. This indicates that they neither died nor were they trapped in the place where they were deposited. The isolated horse teeth indicate stream transportation, though they are not polished. This would suggest that they had been moved but a short distance, since gravel and coarse sand are absent in association with the material. It must be kept in mind that carcasses of dead animals may be washed miles along a stream course, because of their bouyance, and deposited in areas in which they did not live without the bones showing evidence of stream transportation. In the following discussion the assemblage of fossil mammals is treated as having existed as a contemporaneous fauna in the area in which they were collected. It must be kept in mind that this is not a proven fact and certain evidence is to the contrary. Many of the questions arising from this study will require years of careful work for their answer.

The following groupings of the fossil mammals are based upon the adaptive characters presented by them and upon the known habitats of living species of genera represented in the fauna. They are grouped as far as possible under the following communities: upland grass community, semiaquatic community, meadow and marsh community, forest community, and valley slope community. The term community as here employed refers to an assemblage of mam-

mals living under the same, or at least similar, conditions of environment.

Upland grass community: It is assumed that well-developed grassland existed on the upland in this region during the Upper Pliocene because of the abundance of the remains of the horses (*Equus* and *Nannippus*) which are adapted for a grazing habitat. A grassy upland would also furnish a suitable habitat for the camels and the antelope. Smaller mammals of the Rexroad fauna that might also have occurred in the upland association are *Citellus*, *Onychomys*, and *Perognathus*. These genera live in the region at the present time and they also live westward in more arid regions and eastward in a more humid region. It is reasonable to assume that at least one of the Upper Pliocene rabbits inhabited the upland, though there is not enough known of the skeleton of these forms to indicate which were adapted for life on the plains. The badger (*Taxidea taxus*) would undoubtedly be found in the grassland.

Semiaquatic community: The type of deposition of the Upper Pliocene material indicates that there existed a larger stream at that time than the present Crooked creek, in fact a stream comparable to the Cimarron river before the 1914 flood. The presence of the large beaver (*Procastoroides*) in the Upper Pliocene deposit also points to a permanent water supply along the major stream. There is no proof that *Procastoroides* constructed dams as does our present *Castor*. The assumption may be made, however, that if these beavers did not construct dams, they must have lived around permanent bodies of water large enough to furnish a suitable food supply. We cannot believe that the large incisors of *Procastoroides* were adapted for feeding upon grass and aquatic vegetation, and it seems probable, therefore, that the foliage and bark of trees made up a considerable part of the diet of the animal. It seems reasonable to assume that this form constructed dams, even though no evidence of a dam has been found in the deposit. If the beavers constructed dams these must have played an important part in maintaining a slow run-off of surface water and also have helped to maintain a more nearly constant water table in the lowlands throughout the year. In the case that dams were constructed the ponds behind them would provide habitats suited to other vertebrates, such as fishes, amphibians, and birds. The ponds would pass through certain stages in succession, leading to the production of a beaver meadow. A region such as this would support an abundance of plant and animal life.

It should be pointed out at this time that the form *Pliopotamys* which is known from two rami collected by the sifting of the CCC dumps at Localities Nos. 1 and 2, may be a part of a younger fauna, and was considered as an *Ondatra* by Wilson (1933) in the Hagerman fauna. The form may have been semiaquatic in habit though it is not a muskrat. There is no evidence to date as to whether this vole inhabited the stream banks or the meadows and borders of the marshes.

The raccoon would be expected to frequent the edges of the streams and marshes, as it does today.

Meadow and marsh community: The abundance of rami (16) of *Sorex taylori* recovered in good condition from the stream deposit indicates that it was not a desert form, but one that lived along the streams and marshes, apparently in habitats similar to those in which the majority of *Sorex* live at present. *Sorex* is not known to occur in Kansas at the present time. The closest points of known occurrence are northwestern Nebraska and the edge of the Rocky Mountains in eastern Colorado. *Sorex taylori* appears to have been a form living in the meadows and along the marshes and stream banks. If so, it seems to indicate that a lower summer temperature and a slightly more humid condition existed in the region where it lived in the Upper Pliocene than exists there at present. The abundance of genera and individuals of microtine rodents indicate that meadows and marshes existed commonly in the Upper Pliocene valleys. The voles and lemmings are herbivores possessing hypsodont teeth which are adapted for masticating the tender shoots of grasses. Voles, with the exception of the muskrat, are not known to occur in the area at the present time and their abundance in the Rexroad fauna indicates conditions which provided grassy habitats along the valleys. *Ogmodontomys,* a vole the size of a large *Microtus,* is second in abundance of mammals recovered from the deposit. It should be pointed out again at this time that *Pliolemmus,* a lemming, and *Phenacomys* may represent a part of a younger fauna, since they were recovered from the siftings of the CCC dumps at Localities Nos. 1 and 2. At present these forms are found only in boreal faunas. The cotton rat (*Sigmodon*) ranks third in the number of Upper Pliocene individuals collected and also indicates the existence of meadows. *Sigmodon* occurs at the present time in Meade county, where it is confined to the meadows bordering permanent streams and to the edges of marshes bordering the permanent springs. *Baiomys* would be expected to inhabit meadows

and the edges of marshes, if its habits in the Upper Pliocene were the same as those of the species found today on the coastal plains of Texas. The range of living *Baiomys* extends southward through Mexico, from the humid coastal plains well into the high arid plains. It is a genus that apparently possessed a wider range in central and southwestern United States before the Pleistocene than it does at present. *Geomys* may be considered to have inhabited the flood plains, drier regions of the meadows, and the valley slopes where the soil was suitable for burrowing. The moles probably lived in areas of the valleys possessing loose moist soil. Clays, dry packed soil and rocky soil act as barriers to this animal. Moles are common at the present time along the permanent streams of Meade county, especially around cottonwoods where the soil is shaded and remains more or less moist. The habits of the extinct rabbits are unknown. On the basis of material collected, *Pratilepus* is the most common rabbit in the deposit. It is three times as abundant as the other leporids. Because of its abundance it may have been a form that inhabited the meadows near the stream.

Forest community: The presence of mastodonts and deer, which were browsers, would indicate the presence of smaller or larger wooded portions along the stream. This indication supports the evidence furnished by the presence of the beaver. Also, these browsers may have ranged upon the slopes which in suitable areas probably supported trees or shrubs. The wood rat (*Parahodomys*), which is the most abundant form found in the Rexroad fauna, may possibly have inhabited the wooded areas. It may also have lived along the rock ledges, or among the rocks and shrubs on the slopes. This conclusion is based upon the present habitats of the related genera, *Neotoma* and *Hodomys*. *Parahodomys* was present in the Pleistocene Cumberland Cave fauna of Maryland, which points to an ability to live in a more or less wooded region. *Spilogale* would probably be found living in the rock ledges, under rocks along the slopes and in wood rat nests, as it does now in the region.

Valley Slope Community: The valley slope community can only be reconstructed from our knowledge of the existing valley slopes. There would be expected to be two types of slopes along the valleys in the Upper Pliocene as at present. Long, gradual slopes would have extended from the rim of the upland to the valley floor. These slopes would likely be covered with grass. This sort of slope would be used by the grazing forms of the upland as a route in coming down into the valley for water. The steeper slopes would probably be

in part rocky. Some of them also might be covered by scattered shrubs or by shrubs and trees, which would likely provide a habitat for the browsers such as the deer and mastodonts. *Parahodomys* and *Spilogale* might have lived here as has already been pointed out.

It is impossible to suggest the ecological relationships for some of the fossil mammals, since they are known only by extinct forms, of which the habits are unknown.

The extinct genera of cricetid rodents *Eligmodontia*? and *Symmetrodomys* have brachydont teeth, which indicate an omnivorous diet and they may have ranged over several types of habitats. It is impossible to place the rabbits in any one community. Such forms as the carnivores probably ranged throughout most of the area, not being confined to any particular community.

It is possible, after having analyzed present ecological conditions, the data furnished by geological studies, and the evidence offered by a study of the Rexroad fauna of Meade county, to attempt to present a generalized picture of conditions which prevailed at the time the Rexroad fauna was living. Frye (MS) considers the region in southwestern Kansas when the Rexroad fauna was laid down as having been a rolling country, with an elevation approximately the same as at present, traversed by a low gradient stream which was mountain fed, flowing toward the south into the Gulf. The fauna gives evidence that there probably existed along the major stream valley areas of meadows, marshes and trees. It is logical to consider that portions of the steeper valley slopes were covered in part by shrubs and probably trees. These conditions exist in given areas of the county at the present time. The annual summer temperature for the area is indicated by the presence of the shrews and voles to have been somewhat lower than at present. The only vole known, living in the region at the present time is the muskrat, which is confined to the permanent streams. The fissure springs did not exist during the Upper Pliocene, as they come from the buried Upper Pliocene deposits (Frye, MS). The presence of the cotton rat in the Rexroad fauna indicates that the winters were probably no colder than at present, since Meade county is now on the northern limits of its present range. The cotton rat is found in Meade county at the present time, though confined to the grassy areas along the permanent bodies of water. The large number of species of frogs, the numerous land snails supposedly confined to wooded areas, and the presence of the shrew and voles in the Rexroad fauna seem to indicate that the summers were more humid at that time than in the region at the present

and that there were no extreme summer droughts. At least, the climate could not have been drier than at present. It does not seem possible that a permanently flowing stream alone would provide a more humid condition than that of the present in this region, because both Crooked creek and the Cimarron river were permanently flowing until a few years ago; therefore, a higher humidity would seem to indicate a greater rainfall in the Upper Pliocene than at present.

It therefore seems that the fauna as a whole indicates a climate more equable than at present, since the presence of *Sigmodon, Liomys, Parahodomys,* and *Baiomys,* all with southern affinities, indicates somewhat warmer winters; the shrew, voles, lemming and frogs indicate a more humid condition; while the beaver, mastodonts and deer indicate the greater abundance of trees and shrubs than at present. Furthermore, there is no evidence of the existence of great ice fields in the north, nor of cold ocean currents, at that time, which would make extreme winters much less likely than under present conditions.

The possibility must now be considered that the Rexroad fauna may be a mixture of two faunas, that is, *Pliopotamys, Pliolemmus* and *Phenacomys* may belong to a later fauna. In that case the remainder of the fauna would have largely southern and southwestern affinities. The living relatives of the following forms are confined to the southern United States, Mexico or Central America: *Procyon* (subgenus *Euprocyon*), *Spilogale rexroadi, Liomys, Perognathus, Onychomys, Baiomys, Peromyscus* (subgenus *Haplomylomys*), *Sigmodon, Parahodomys, Eligmodontia*? and *Symmetrodontomys.* If the fossils do belong to two distinct faunas the older or Rexroad proper would indicate clearly a warmer and more humid climatic condition than exists in that region at present.

On the other hand, if the Rexroad fauna is not mixed and represents a contemporaneous group of mammals then the presence of the lemming and *Phenacomys,* which are boreal forms, would indicate a cooler climate than the present or at least cooler summers At the close of the Pliocene there was a slow shifting toward a cooler climate over the whole continent, with a chance for an invasion of forms from a more northern fauna.

## SUMMARY

The Rexroad mammalian fauna from the Upper Pliocene of southwestern Kansas contains 8 orders consisting of 37 identified genera. Of these genera 10 were new. There are 32 identified species, of which 25 were new. The fauna was collected from a stream deposit consisting of sandy silt containing lenses of fine sand, from clay and from bog material.

On the basis of the fossil mammals the Rexroad, Blanco, Benson and Hagerman faunas are considered to be of approximately the same age. The differences between the faunas are considered to be only of geographical significance. The Rexroad fauna shows a closer relationship to the Blanco and Benson fauna than to the Hagerman fauna. While the fauna as a whole shows relationships with forms now found in Mexico and Central America rather than with the recent forms now found in southwestern Kansas, a few fossil forms possess boreal affinities.

From geological interpretation by Frye the fauna inhabited a rolling country approximately at the elevation of the region today. The region was traversed by a major stream of low gradient which was mountain fed and flowed southward toward the Gulf.

From the study of the Rexroad fauna there is evidence which indicates the existence of the following communities in southwestern Kansas at the time the fauna lived; upland grass community, semi-aquatic community, meadow and marsh community, forest community and valley slope community. The fauna indicates that meadow flats and timbered areas existed at least along portions of the Upper Pliocene stream valley, and that the climatic conditions then were not drier nor colder than at present. Moreover, there is some indication that climate in the Upper Pliocene was more equable than at present, without extremely cold winters or severely hot summers, and that there was a somewhat greater degree of humidity.

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THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XXVII] NOVEMBER 1, 1941 [No. 7

# Herpetological Miscellany, No. II

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ABSTRACT: In this paper the following new species are described from Mexico: Order Caudata, Family Plethodontidae, *Thorius dubitus,* Acultzingo, Veracruz; *Thorius troglodytes,* Acultzingo, Veracruz; *Bolitoglossa chondrostega,* Durango, Hidalgo; and *Bolitoglossa terrestris,* near Tianguistengo, Hidalgo. Order Anura, Family Hylidae, *Hyla arboricola,* near Omilteme, Guerrero. Order Serpentes, Family Colubridae, *Geophis maculiferus,* near Cício, Michoacán; and *Oxybelis potosiensis,* 38 Km. N. W. Cuidad Maiz, San Luis Potosí; Family Crotalidae, *Crotalus triseriatus gloydi,* Cerro San Felipe, Oaxaca, Oaxaca. Several other known species are discussed and figured.

THE genus *Thorius* was proposed by Cope in 1869 for a small salamander having the "parietal and palatine bones rudimental, represented by cartilage and membrane," which he named *Thorius pennatulus.* It was likewise on the basis of this species that the family THORIIDAE was proposed. Two other diminutive species of the genus have been described. These are *Thorius narisovalis* Taylor (1940) and *Thorius pulmonaris* Taylor (1940) from Cerro San Felipe near Oaxaca, Oaxaca.

At various times I have obtained specimens of the genus *Thorius* from near Acultzingo, at the summit of the mountains where the highway crosses. I referred the specimens to *Oedipus pennatulus* (Cope) (Taylor, 1939) and later to *Thorius pennatulus* Cope (Taylor, 1940), calling attention to the fact that apparently two forms were present in the specimens collected. In 1940 I was able to examine large numbers of a species of *Thorius* collected by Dr. and Mrs. Hobart M. Smith at Cuautlapan, Veracruz, and to visit this locality myself and collect large series of the same species. This species is different from the two forms occurring at Acultzingo. The

locality Cuautlapan is a few miles north of Orizaba, and only a few hundred feet lower. The locality near Acultzingo is perhaps 25 miles south of Orizaba and several thousand feet higher.

The type of *Thorius pennatulus* is apparently lost and I am confronted with the necessity of determining which, if any, of these three forms is *Thorius pennatulus* Cope. The cotypes, 7 in all, originally bore the numbers USNM 6341 (six specimens) and 6744, color variety (1 specimen). No specimens bearing these numbers can be found in the National Museum today. Dr. Emmet Reid Dunn, in his study of the PLETHODONTIDAE, suggests that these cotype specimens (collected by F. Sumichrast at "Orizava," Mexico) are now catalogued under the numbers ANSP 1269 (three specimens "Orizaba" collected by Sumichrast and USNM Nos. 30348-30349, 25101 no data, returned from Philadelphia after having been in the hands of E. D. Cope); and 30352, having the same history. This last specimen was placed in the species *Oedipus* [= *Bolitoglossa*] *townsendi* by Dunn when he described that species.

I have examined the presumed cotypes in the National Museum, 25101, 30348, 30349. The first of these consists of several body fragments with part of the head. The snout is missing, part of the jaws cannot be discovered. I find none of the limbs, and cannot be certain that the species belongs to the genus *Thorius*. (This could be determined by a study of the individual components of the skull.) No. 30348 consists of a head and part of the neck, and a fragment with several vertebrae. This is possibly a specimen of *Thorius*, but the nostril is small, less than half the size of the nostril in the Cuautlapan specimens. The skin is very smooth on the head and the snout is very narrow and pointed. If this is a specimen of *Thorius* it is not the species from Cuautlapan. No. 30349 consists of a small fragment of the body of a salamander, and unless the character of the few vertebra should prove diagnostic, cannot be certainly placed in the genus *Thorius*.

Certain other old specimens identified as *Oedipus pennatulus* in the National Museum have been examined. These are USNM No. 47798, a hardened, shrivelled specimen which appears to be a specimen of *Thorius pulmonaris*, Reyes, Oaxaca; No. 47608, a hardened specimen, appears to be of *Thorius narisovalis*, Cerro de San Felipe, Oaxaca.

Specimens of *Thorius* in the British Museum coming from 9,000 to 10,000 feet elevation on Mt. Orizaba (Xometla), as well as specimens designated as from "Orizaba," have been referred to *pennatulus* (Dunn, Plethodontidae, p. 365-439). In consequence, I have in

the past presumed that the type locality "Orizava" referred to the mountain rather than to the city.

Since a species of *Thorius* has been discovered near Orizaba and at the same approximate elevation, it is probable that the types as well as certain other specimens in the British Museum labeled "Orizaba" are from near the city. Thus it becomes reasonably certain that the type locality actually refers to Orizaba city rather than to Mt. Orizaba. Another point in favor of this view is that mixed with the *Thorius* collected by Smith are several specimens of a diminutive bolitoglossid salamander which agree with my paratypic specimen of *Bolitoglossa townsendi* (Dunn); and certain evidence points to the fact that the specimen in the National Museum referred by Dunn to this species was likewise collected with *Thorius pennatulus*.

It seems probable that the high mountain specimens, 9,000-10,000 feet elevations (Xometla), should be referred to a species other than *pennatulus* Cope.

Since there is no absolutely authentic type I propose to designate one of Smith's recently collected specimens as a neotype, USNM No. 111017, so that it may be of value for reference to future workers.

### KEY CHARACTERS OF THE SPECIES OF THORIUS

A. Nostril large, oval, greatly elongated, nearly twice as long as wide. Foot and hand broadened, the digital tips more or less pointed; premaxillary teeth apparently never piercing upper lip in males. (Cerro San Felipe and Cerro San Luis, near Oaxaca, Oaxaca.)..... *Thorius pulmonaris* Taylor.

AA. Nostril large, round or oval, never greatly elongated.

B. Nostril very large, circular; digits pointed; usually a single premaxillary tooth piercing lip; subnarial swelling pendant; submental gland very distinct. (Region about Orizaba city and Cuautlapan, Veracruz.).. *Thorius pennatulus* Cope.

BB. Nostrils large, oval; digits rounded at tips; one or two premaxillary teeth piercing lip. Subnarial swelling not pendant.

C. Skin of head smooth or with only a faint trace of pitting; the upper extension of hyoid (epibranchial) reaches level of arm insertion; usually a single tooth piercing lip; body and tail more or less compressed. (Mountain summits near Acultzingo, Ver.)..... *Thorius dubitus* sp. nov.

CC. Skin of head usually more or less pitted; upper extension of hyoid (epibranchial) usually extending to at least posterior level of arm or farther; body not compressed, but rounding or somewhat flattened; tail more or less cylindrical at base.

D. Larger; maximum snout-to-vent length, 32 mm.; head and body strongly pitted; three premaxillary teeth pierce lip; nostril larger; about 35 caudal grooves in full-grown specimen. Found above ground under bark of rotting logs. (Cerro San Felipe and Cerro San Luis, Oaxaca.)..... *Thorius narisovalis* Taylor.

DD. Smaller; maximum snout-to-vent length about 26 mm.; head and body usually dimly (rarely distinctly pitted); usually one, rarely two, premaxillary teeth pierce lip; nostril proportionally smaller; about 40 caudal grooves; dorsum lighter; found under rocks or in cavities in clay, animal burrows, etc. (Region above Acultzingo.) *Thorius troglodytes* sp. nov.

### *Thorius dubitus* sp. nov.

(Plate III, fig. 3)

*Thorius pennatulus* Taylor, Univ. Kansas Sci. Bull., XXVI, 1939 (Nov. 27, 1940), pp. 414-416 (*part*), pl. XLVII, fig. B.

*Type.* EHT-HMS, No. 17751, collected at summit of mountain about two miles south of Acultzingo, Veracruz (near Puebla line), in moss, July 20, 1938, by E. H. Taylor.

*Paratypes.* EHT-HMS, Nos. 17731-17750; 17752-17786; 22064-22084; USNM Nos. 110984-110991; 110993-111007; 111009-111011. All topotypes.

*Diagnosis.* A diminutive species, maximum size (head-body length) 22 mm.; 13 costal and about 35 caudal grooves; body somewhat compressed, deeper than wide; tail distinctly compressed, quadrangular; groove below eye tending to bisect line of mouth anterior to the posterior corner of eye; posterior hyoid extension reaches posteriorly to level of arm insertion; nostril large, oval; subnarial swellings moderate; mental gland distinct; premaxillary tooth pierces the lip; adpressed limbs separated by 5-5½ costal folds; lighter dorsal marking terminates at tail.

*Description of the type.* Adult male; head and neck a little wider than the body, and relatively low; distance between orbits minutely greater than width of an eyelid; nostril large, oval, diagonally placed, about .5 mm. in greatest diameter; subnarial swelling distinct, not pendant (as in *pennatulus*); eye large, about equal to length of snout; a slight diagonal fold indicated behind posterior corner of eye, but not concealing the terminal portions of eyelids; parietal and interorbital regions of head flat, slightly lower than level of snout; groove behind eye faintly indicated; a strong groove running below orbit bisects line of mouth anterior to posterior point of eye; an indistinct groove crosses throat and extends across jaw angles; a groove forming an arch rests on the transverse groove and reaches forward to near the submental gland; a strong nuchal fold crosses throat curving back; from this a deep irregular groove ascends the sides of the neck and joins its fellow from the opposite side on the middorsal line; musculature on the neck causes a curving lateral fold of skin on side of neck; elevation caused by superior hyoid extension reaches posteriorly barely to level of arm insertion; 13 costal grooves, most of which can be traced across abdomen.

Tail somewhat constricted in cloacal region, distinctly quadrangular and laterally compressed to tip; about 33 caudal grooves (tail complete); a distinct linear depression along the median dorsal line;

more or less continuous along the middorsal line of the back; adpressed limbs separated by about 5 costal folds; limbs short, the tips of the two middle fingers free, rounded at tips; outer fingers adhering to sides of the middle fingers, without free tips or web; order of length, 1, 4, 2, 3; subterminal pads moderately distinct; toes in the following order of size, 1, 5, 2 = 4, 3; the three middle toes with the first joint free, their ends rounded; fifth toe very narrow, without free tip; first toe wide, likewise without free tip.

Tongue boletoid, somewhat elongate, the anterior part attached to stalk, free behind; a small sublingual fold with free edge; a single premaxillary tooth pierces the lip a little back of the edge; six vomerine teeth on a transverse ridge, arranged in two rather irregular series, separated medially, not reaching inner level of choanae; latter small, narrow, oval, more or less continuous with the deep groove which emerges from them; parasphenoid teeth in a single series, narrowed anteriorly, widened posteriorly, separated from vomerine teeth by a distance about equal to width of the two vomerine series; mandibular teeth minute, about 14 on each side.

Skin very smooth without distinct pits on head or body (indistinctly pitted in certain paratypes).

*Coloration.* Brownish above on back; sides blackish, growing lighter towards venter, which is light brown; no white flecks on chin or venter, but the chin is somewhat lighter than venter; upper surface of tail darker than body, lacking a dark lateral stripe.

*Measurements of type in mm.* Snout to posterior end of vent, 21; tail, 23; total length, 44; width of head, 2.8; head to gular fold, 3.9; axilla to groin, 11.3; snout to arm insertion, 6.5; arm, 3.5; leg, 4.

*Remarks.* This diminutive species varies but little in the large series. All were taken in a deep mass of moss and other plants growing at the base of a lone pine tree. The method of collecting consisted in uprooting pieces of the thick turf, tearing them to pieces, and shaking them. The salamanders were usually coiled in watch-spring spirals and would remain motionless in this position when exposed, as if feigning death. Associated with them were numerous small millipeds which were similarly coiled and of the same general color. Nearly a hundred of these salamander specimens were obtained from an area less than four meters square.

The specimens were killed by immersion in weak alcohol and all tended to die in rigor mortis, the body forming a downward curve, the tail curving upward. Specimens of *Thorius troglodytes,* sp. nov. found in the vicinity, usually under rocks in clay soil, when killed in the same identical liquid, remained relaxed and straight.

Similar results were obtained with the two forms with alcohols of different concentrations. This suggests distinct physiological as well as morphological differences in the two forms.

The three figures given in my previous work (Taylor, Nov., 1940, *loc. cit.*, pl. XLVII, fig. B, "*Thorius pennatulus*") show the more salient characters of the head of the type, and offer a comparison with similar figures of *Thorius troglodytes* (Fig. A, "*Thorius pennatulus*") and *Thorius narisovalis* (Fig. C.).

### *Thorius troglodytes* sp. nov.

(Plate III, fig. 4)

*Thorius pennatulus* Taylor, Univ. Kansas Sci. Bull., XXV, No. 14, 1938 (mailing date, July 10, 1939), pp. 293-294 (Acultzingo); and *idem.*, XXVI, 1939 (mailing date, November 27, 1940), pp. 414-416 (*part.*), pl. XLVII, fig. a.

*Type.* EHT-HMS, No. 17791, collected along old road on mountains about two miles south of Acultzingo, Veracruz, July 10, 1938.

*Paratypes.* EHT-HMS, Nos. 12142-12143; 17789-17790; 17791A Topotypes. USNM, Nos. 110961-110972, 110974-110983; 110992 Topotypes.

*Diagnosis.* A species intermediate in size in the genus, maximum length, snout to posterior end of vent, 26 mm.; groove below eye usually intersects the line of mouth below the posterior corner of eye; nostril oval, large, the subnarial swelling small; body flattened rather than compressed; tail not, or but very little compressed; dorsal coloration continued on dorsal surface of tail to tip; sides darker, gradually growing lighter towards venter; chin and region below neck with numerous whitish flecks; 13 costal, and about 40 caudal grooves; pitting on head more or less distinct.

*Description of type.* Adult male; head slightly wider than neck, not distinctly wider than body; parietal region slightly curving rather than flat; eyelid little raised, narrower than interorbital distance; eye large, longer than snout, but about equal to its distance from the tip; nostril oval, large, diagonally placed, at least half diameter of eye; subnarial swellings present, not beadlike or strongly pendant; a very slight diagonal fold is visible at the posterior corner of the eye, beneath which the posterior parts of the eyelid tend to terminate; the groove below the orbit intersects the line of the mouth almost directly below the posterior corner of the eye; a groove crossing the jaw angles barely reaches the lower level of the eye, and can be traced across the throat, but usually not in a continuous line; an irregular groove arches from this groove as a base, and extends forward, almost in contact with the enlarged submental gland; the

arch itself more or less angulate; a strong nuchal fold crosses the throat, curving back, and from its sides arise shallow grooves which continue to the median dorsal surface; there is not or at least only a faint suggestion of a longitudinal groove back of the eye (apparent if the specimens are somewhat desiccated); the concealed musculature of the neck does not form curving folds; the elevation caused by the posterior hyoid extension reaches almost to the first intercostal fold; 13 costal grooves; practically none of which can be traced completely across the abdomen; tail minutely higher than wide, nearly cylindrical; 35 caudal grooves; the tip of the tail apparently complete; a discontinuous, shallow, median, dorsal groove, more or less indicated, which is not continued on to the tail; a distinct constriction at the base of tail, posterior to the vent; the adpressed limbs are separated by 5½ costal folds; arm short, the tips of the two middle fingers oval with at least one free joint; the tip of the outer finger free; that of the first finger completely fused to the side of the second, leaving a somewhat rounded knob; three middle toes with tips rounded; at least with one free joint; inner toe with tip free; outer toe fused to the side of the fourth, without free tip; the second and fourth toes about equal in length, the middle longer.

Tongue boletoid, somewhat elongate, with a slight sublingual fold; the attachment is at the anterior point of the tongue, the posterior part free; no maxillary teeth; 2 premaxillary teeth pierce the lip; about 18 mandibular teeth on each mandible; vomerine teeth on a ridge across palate, 4 or 5 on each side separated somewhat, medially; parasphenoid teeth in a single series, narrowed anteriorly, widened posteriorly, separated from the vomerine series by a distance equal to the width of the vomerine series.

Skin of the head showing shallow pits; skin of the dorsal surface of the body very smooth; skin between the costal grooves somewhat pitted, but not longitudinally wrinkled.

*Coloration.* Light brown above, slightly darker on the head with a faint trace of a dorsal line of darker spots; sides darker brown, growing lighter on the venter, which is fairly heavily pigmented with light brown; chin and throat with numerous cream flecks; the dorsal coloration of body is continued on to the tail; subnarial swellings grayish white.

*Measurements of the type in mm.* Snout to the posterior end of vent, 26; tail, 30.5; total length, 56.5; head width, 2.1; head to gular fold, 4.15; axilla to groin, 15; snout to arm, 6.5; arm, 3.4; leg, 4.

*Remarks.* The variation observable in the form is not great. In

some specimens the distinctness of the pitting is greater than in the type, and in certain ones possibly less distinct. Females are slightly darker, in general, than the males and the contrast of the dorsal and lateral coloration is somewhat less. There is a slight variation in the number of teeth; several of the specimens have only a single premaxillary tooth piercing the lip, and the number of mandibular teeth varies between 16 and 20; in some cases the vomerine teeth are not arranged in a linear series. The choanae are small and oval.

The skulls apparently have very little calcium, and the individual bones do not maintain their shape when dried. The small gland behind the insertion of the femur is present.

A number of specimens show a regenerated tip on the tail. As previously recorded (Taylor, 1940) some of the specimens have the tip of the tail infested with a small worm below the epidermis, and it is possible this is responsible for the loss and subsequent regeneration of the tip. It was likewise noted that numerous specimens of *T. dubitus* show similar regeneration.

A single specimen from Toxtlacuaya, Veracruz, from a lower elevation, is present in the collection. The particular specimen has the nostril very greatly reduced in size, and I suspect that it represents an undescribed form. I am holding this specimen, trusting that a series may be available before its characteristics are described in detail.

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The distribution of the amphibian fauna in the state of Hidalgo is somewhat puzzling. This region appears to be a meeting place of three faunal subprovinces.

The mountains of the southern part of the state reach an elevation of about 10,000 feet, and have much pine and other cone-bearing trees. Here at the highest elevation the amphibians are *Bolitoglossa multidentata, B. dimidiata, Hyla eximia, Hyla lafrentzi, Hyla forbesorum, Rana sp.,* while at a somewhat lower elevation *Bolitoglossa manni,* and *B. belli* occur.

To the northeast and separated by the deep and narrow valley of the Rio Amo, the largest branch of Rio Panuco which empties into the Gulf of Mexico farther to the north, there is a region that differs considerably from the Pachuca region in its fauna. The maximum elevation is probably less than 8,000 feet and the average elevation is perhaps near 6,000 feet. Here the characteristic salamanders are *Bolitoglossa terrestris* sp. nov., *B. gigantea, B. sp.* (related to *cephalicus*). and *B. arborea.* The Anuran group shows *Rana pipiens* var..

*Hyla baudinii, H. robertsorum, H. eximia, H. bromeliana, H. miotympanum, Syrrhophus verrucipes, S. verruculatus,* and *Eleutherodactylus sp.*

Certain very distinctive reptiles are known. These are *Lepidophyma sylvatica, Micrurus bernardi, Thamnophis halophila, Geophis multitorques, Storeria sp., Storeria dekayi* var., and *Leptodeira septentrionalis.*

To the west and northwest the state has less rainfall, and in some localities it may assume a semidesert appearance. The high forest contains pine occasionally and there is much exposed limestone, especially in the north.

Here the character of the fauna changes again and the salamanders are represented by *Bolitoglossa chondrostega* sp. nov., *B. belli, B. sp.;* the Anura by *Syrrhophus latodactylus, Tomodactylus macrotympanum.* The reptiles have *Leiolopisma forbesorum, Gaigia gageae, Rhadinaea gaigeae,* and *Crotalus molossus nigrescens.*

The species listed do not represent the total fauna of the areas, but are, for the most part, forms apparently confined to or appearing in a single region. Future collecting may change this picture, showing that these forms are more widely spread in Hidalgo, but it is quite as likely that the discovery of more new endemic forms will establish these faunal areas on a firmer basis.

In this paper I include descriptions of two of the undescribed forms.

*Bolitoglossa chondrostega* sp. nov.

*Type.* EHT-HMS, No. 17304 ♂ ; collected at Durango, Hidalgo, 5,000 to 6,000 feet elevation, September 12, 1938, by E. H. Taylor.

*Paratypes.* EHT-HMS, Nos. 17283-17303; 17305-17310. Topotypes, same data as type.

*Diagnosis.* A small salamander presumably a member of the *chiropterus* group, resembling *chiropterus*, but differing in having the dorsal roof of the skull largely of cartilage. The mandible likewise is largely cartilage. Form similar to *chiropterus*, but the foot is much smaller, the teeth more numerous in the males.

*Description of the type.* Eye very large (2 mm.), its length greater than the length of the snout (1.7 mm.); snout strongly rounded in front of eyes, truncate at end; subnarial swellings prominent, the nostrils small; groove below eye terminates below eye and fails to reach posterior level; line of mouth curving slightly between narial swelling and its posterior angle; snout extends somewhat beyond tip of lower lip; width of an eyelid slightly less than interor-

bital distance; a strongly developed, free, sublingual fold crenellated on front edge; tongue large, free; vomerine teeth 7-7 in two curving diagonal rows on a transverse ridge, separated narrowly medially, extending to outer level of the very small choanae; parasphenoid teeth in two series widely separated from the vomerine series; maxillary-premaxillary teeth 17-16, the teeth variable in size; the premaxillary teeth pierce the gums just back of the edge of the lip (females with 20-20 teeth which are more uniform in size); mandibular teeth 20-20, a little larger than those in maxillary (female 22-20, and distinctly shorter than those in males). A faint trace of a groove behind eye; a vertical groove crosses angle of jaw visible ventrally for a short distance; gular fold strong, the grooves arising from its ends ascend to median line on neck; a faint groove between the two vertical grooves above which are four island-like areas; 13 well-defined costal grooves, not, or scarcely visible on sides of venter; cloacal wall papillate; skin of head and body more or less distinctly pitted; limbs, when adpressed, are separated by about two costal folds; first finger and toe involved in web without free tip; other digits with one or two joints free, the tips oval with well developed subterminal pads; the toes are held spread apart; tail slightly compressed, constricted at base; about 30 caudal grooves, the distal ones very indistinct; mental gland not well defined externally; a small glandular spot behind insertion of femur.

*Color.* Above grayish plumbeous to lavender, growing lighter on sides; venter with uniform pigment, appearing dull, dirty cream, without spots or blotches; when held under water, a very faint dorsolateral dark line can barely be distinguished.

*Measurements in mm.* Snout to vent, 29; tail, 34; head width, 4.4; head length to gular fold, 6.3; axilla to groin, 14.5; snout to forearm, 9.4; arm, 6.5; leg, 6.5.

*Remarks.* The species is most closely related to *Bolitoglossa chiroptera*, from which it differs in smaller size, larger series of mandibular teeth in males (22-17), smaller feet, and a more poorly ossified skull. From *B. multidentata* it differs in having shorter limbs, very much smaller feet, and a much narrower head.

The species belonging to the *chiroptera* group of the genus *Bolitoglossa* seem to have a varied series of color patterns that are found in the several species; these consist of: (1) nearly uniformly colored individuals lacking distinctive patterns; (2) a pattern in which there is a median stripe of the darker ground color, bordered dorsolaterally by cream colored stripes; (3) a pattern in which the dorsal

surface (or at least the medial part) will have a light stripe of cream-orange or red-orange. In these cases there is usually more lateral pigmentation, and, by contrast, is darker.

These patterns are present, at least, in the following species of the group: *chiroptera, chondrostega, xolocalcae, terrestris,* and to a lesser extent in *arborea.*

*Bolitoglossa terrestris* sp. nov.

*Type.* EHT-HMS, No. 23354 ♂ ; collected July 1, 1940, about six miles south of Tianguistengo, Hidalgo, Mexico, at an elevation of about 5,000 feet, by Edward H. Taylor.

*Paratypes.* EHT-HMS, Nos. 17311-17359, 23244-23310, five to six miles north of Zacualtipan, Hidalgo, Richard C. Taylor and Edward H. Taylor; Nos. 23311-23405, four to ten miles south of Tianguistengo, Hidalgo; same collectors.

*Diagnosis.* A small salamander of the Chiroptera group having a tail as long as or slightly longer than snout to vent measurement; teeth in male reduced in both upper and lower jaw, the teeth bent back and slightly hooked; skull and jaw ossified; limbs separated by 1½ (male) to 3 folds (female) ; usually a dark lateral line, interrupted at shoulder; maximum size about 31 mm., snout to vent; total length, 60 mm.

*Description of the type.* Head not, or but minutely, broader than body; eyes prominent, their length (1.6 mm.) less than length of snout (1.9 mm.) ; snout rounding above, lacking a canthus; subnarial swellings distinct, but small; nostrils very small, oval, the groove from them runs back, then curves down to the swelling; end of snout rather truncate, but seen in dorsal profile is somewhat curved and extends beyond lower lip; eyelid in interorbital distance more than one and one-third times; premaxillary teeth 4-5, elongate, protruding immediately behind the edge of the lip or actually through the edge; parasphenoid teeth in two series, widely separated from vomerine teeth; maxillary-premaxillary series, 13-14, the teeth not of equal size; mandibular teeth about 14-15, likewise unequal; vomerine teeth, 5-4, not or scarcely separated medially on a somewhat elevated ridge, not reaching beyond the outer level of the small circular choanae; tongue free, large, with a distinct sublingual fold; the corners of the eyelid do not fit under a diagonal fold, although a trace of the latter can be seen; groove from corner of eye back across temporal region wanting (can be seen in slightly desiccated specimens) ; skin more or less pitted; a well-defined groove runs

across throat, crosses angle of jaws, runs up to level of eye, and divides, one branch going forward a short distance, one backward and upward; gular fold ample, the grooves emerging laterally continue to the median dorsal line; a groove appears between the two vertical grooves, above which, the skin forms islandlike areas; there are 11 well-defined costal grooves, the axillary and inguinal wanting, save for tiny grooves high on the sides; grooves do not continue across venter; cloacal walls papillate (folded in female); the cloacal region swollen with a fleshy flattened cream-colored body emerging from cloaca (present in most males, perhaps spermatophore ?).

Limbs well developed, the first finger and toe included in the web save for the extreme tip; third finger and toe longest, the other digits subequal in length; the web includes the proximal phalanges, but is somewhat excised between them; when adpressed, the limbs are separated by about one and one-half costal folds. Mental gland distinct; a small glandular patch behind insertion of femur; tail rather cylindrical, somewhat narrowed at base.

*Color.* Above variegated lavender to brownish lavender with occasional minute darker or lighter flecks; snout a little lighter than top of head. An indefinite darker lavender to purplish dorsolateral stripe runs to eye, but is interrupted on shoulder where somewhat reddish markings intervene; below, dirty cream with a slight scattering of pigment.

*Measurements in mm.* Snout to end of vent, 26.5; tail, 29; width of head, 4.5; length of head to gular fold, 7.3; snout to arm, 8.6; axilla to groin, 14.8.

*Variation.* The teeth in the females are more numerous, about 25-25 in the maxillary-premaxillary series and a similar number in the mandible. The average axilla to groin distance is greater in females than in the males; the head is a little thicker and wider and they attain a slightly greater size.

In life many of the specimens had red spots on the femur and reddish markings in the nuchal region. A few had the backs red or reddish orange, more intense on neck (the red soon fades in preservation); young females and a few adult females, as well as a few young males, have more pigment on the belly, showing inclosed cream flecks.

The lateral dark stripe and the light area on the snout are often obscured if the specimen is dark; but prominent if the animal is light. A few of the specimens have a pair of cream (red) dorsolateral lines.

*Remarks.* One specimen (No. 23344) had just eaten a tiny specimen of salamander, apparently the young of the same species.

The "organ" extruded from the cloaca, takes its rise from the two glands lying at the sides of the cloaca. About a half of the free end is visible externally, which becomes twisted sometimes by preservation.

Another species in which I have found a similar projection from the cloaca is *Bolitoglossa dimidiata*. I have found nothing of this sort in *B. multidentata*, *chiroptera* or *B. chondrostega* taken at the same time of the year.*

One female examined had 13 large, nearly ripe, ovarian eggs.

*Eleutherodactylus mexicanus* Brocchi

In a recent paper I have discussed four frogs (Taylor, Some Mexican Frogs. Proc. Biol. Soc. Washington, Vol. 54, July 31, 1941, pp. 87-94) of the *mexicanus* group of the genus *Eleutherodactylus*. I endeavored to show that the name *mexicanus* apparently applied to the southeastern Mexican frog that has the vomerine teeth absent or at least greatly reduced. The forms *Hylodes calcitrans* Günther, *Borborocoetes mexicanus* Boulenger, *Leipurus mexicanus* Brocchi and *Eleutherodactylus saltator* Taylor have been confused, at least the three first have been placed in three different genera, by as many authors and by a more recent author in a single species. I am providing figures here to show some of the salient body characters that are difficult to visualize from written descriptions. It is obvious that the *mexicanus* of Boulenger is preoccupied by *mexicanus* of Brocchi. In consequence I have given the name *Eleutherodactylus occidentalis* to the Boulenger species.

The following species are illustrated: *Eleutherodactylus saltator* Taylor (plate IV, fig. 2), *Eleutherodactylus occidentalis* Taylor (plate IV, fig. 1), and *Eleutherodactylus calcitrans* Günther (plate V, fig. 2).

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In a recent paper dealing with the *eximia* group of the genus *Hyla*, I noted the apparent absence of a representative of this group in the territory south of the Balsas Basin in the state of Guerrero. During my sojourn in this region in 1940 a new species belonging to this group was discovered west of Chilpancingo at a point not far from Omilteme at an elevation between 7,500 and 8,000 feet. Specimens

* Specimens of these forms were sent to the late Dr. G. K. Noble, who agreed to make a study to determine whether the cloacal bodies were typical spermataphores or whether something in the nature of a temporary intromittent organ. Whether he completed this study is not known.

were first encountered in a small natural pond, in the very narrow valley between two mountains where the species was breeding. The pond was some fifty feet in diameter and not more than three feet deep. All about the edge in the shallow water were numerous egg masses. A few pairs were clasping at 3:30 p. m. Several specimens were collected at this time. On my return journey about forty-eight hours later no specimens were at the pool. However, a search in the vicinity resulted in their discovery in bromeliad plants within a hundred meters of the pool. Several more specimens were obtained as I examined the plants. I propose to distinguish this species as *arboricola* sp. nov.

*Hyla arboricola* sp. nov.

(Plate V, fig. 1)

*Type.* EHT-HMS, No. 24556 ♀. Collected at an elevation of about 7,000 feet about six miles east of Omilteme, Gro., Mexico, August 5, 1940, by Edward H. Taylor.

*Paratypes.* Nos. 24557-24588, topotypes.

*Diagnosis.* A member of the *Hyla eximia* group, but with head as broad as or broader than body; no well-defined black and cream line on side of head; dark markings on back not bordered with cream; posterior and anterior face of femur with uniform pigmentation; limbs lacking black bars or marks; tibiotarsal articulation reaches the anterior part of eye; web extends beyond the distal subarticular tubercles; a canthus rostralis.

*Description of the type.* Eye moderately large, its length (3.5 mm.) equal to its distance from the nostril, less than length of snout (5.5 mm.); upper eyelid (3 mm.) less than interorbital distance (4.1 mm.); length and width of head about equal; diameter of tympanum (2.1 mm.) a little less than its distance from posterior corner of eye; canthus somewhat rounding, the lores not, or but slightly, concave, sloping to lip; region about nostrils somewhat swollen.

Tongue rather small, subcircular, a little longer than broad, slightly nicked behind; (vocal sac present in males); vomerine teeth 5-5 in two raised areas wholly between and equal in size to the large choanae, separated from the latter by a distance equal to near the width of one group, and very narrowly separated from each other; maxillary glands open into a sinuous groove about midway between choanae and premaxillary.

Dorsal surface smooth or minutely corrugated when seen under a lens; all ventral surfaces heavily granular; sides of body likewise granular; a well-defined fold on breast; a groove behind anal open-

ing; the anal flap not elongated; only a trace of a web between fingers; well-developed terminal disks which are a little wider than those on toes; well-developed subarticular tubercles with numerous other irregular granules; three more or less distinct enlarged palmar pads and an elongate pad on base of the first finger; webs on toes attach a little in advance of the distal tubercles except on fourth finger, which has two joints nearly free; inner metatarsal tubercle large, longer than wide; a small, indistinct outer tubercle; a high fold extends length of tarsus; when limbs are folded at right angles to body the heels overlap about two millimeters.

*Color.* Uniform gray-green on dorsal and lateral surfaces, with faint traces of elongate darker markings; sides of head lighter green; all ventral surfaces cream, including undersurfaces of sole, palm and digits. The males are smaller and the markings more distinct.

*Measurements of type in mm.* Snout to vent, 37.5; head width, 14; head length, 13; arm, 25.5; leg, 60.5.

*Remarks.* The relationship of this species is probably closer to *Hyla euphorbiacea* and *Hyla eximia* Günther than to other members of the group. From the former it differs in lacking the markings on the posterior femoral region, has more web on feet and larger pads. When it is directly compared with *Hyla eximia* from Puebla and Michoacán the following differences are evident: head shorter and proportionally a third (or more) wider in specimens of equal size; the snout much less pointed; the webbing is distinctly greater between the toes, and the terminal pads are proportionally larger. The dark and light stripes on upper labial region wanting, or so indistinct that they are not discernible; the canthus is more distinct.

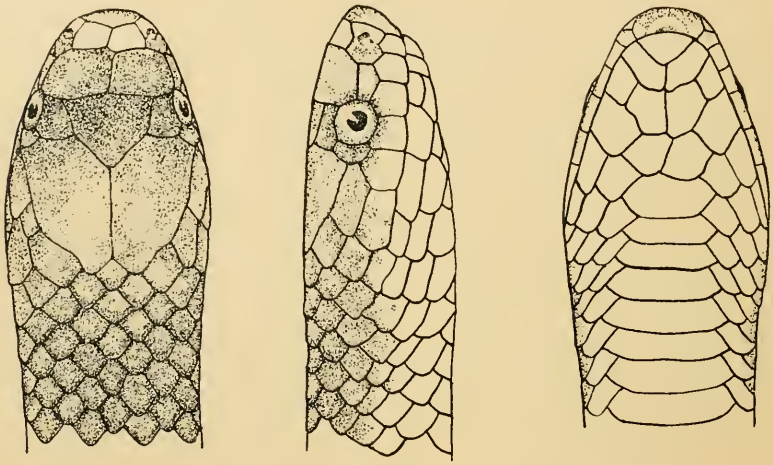
*Geophis maculiferus* sp. nov.

*Type.* EHT-HMS, No. 23552, collected on the "Huetamo" road near the village of Cício, Michoacán, 17 Km. south of the Mexico-Guadalajara highway, August 14, 1940, by Edward H. Taylor.

*Diagnosis.* Belonging in the *Dirosema* section of the genus. A large anterior temporal; 6 upper labials, last largest; frontal one-third wider than long; rostral narrowly visible above; supraoculars relatively large; labials, internasals, and ventral surfaces creamy or yellowish white.

*Description of the type.* Rostral much wider than high, narrowly visible above; internasals wider than long, their posterior sutures transverse; prefrontals very large, subquadrangular, their mutual

suture more than half length of frontal, entering eye, touching loreal (preocular) and posterior nasal, laterally; frontal nearly triangular, its anterior angle very obtuse, barely reaching anterior level of eye, much shorter than its distance from end of the snout; parietals elongate, their length greater than their distance to end of snout; nasal divided, the nostril almost wholly in the anterior; loreal about twice as long as high, the anterior and posterior ends parallel, its upper edge a straight horizontal line, its length equal to its distance from nostril; supraocular nearly as wide as long; one postocular;



TEXT FIG. 1. *Geophis maculiferus* sp. nov. Type. EHT-HMS, No. 23552; near Cício, Michoacán. × 5.

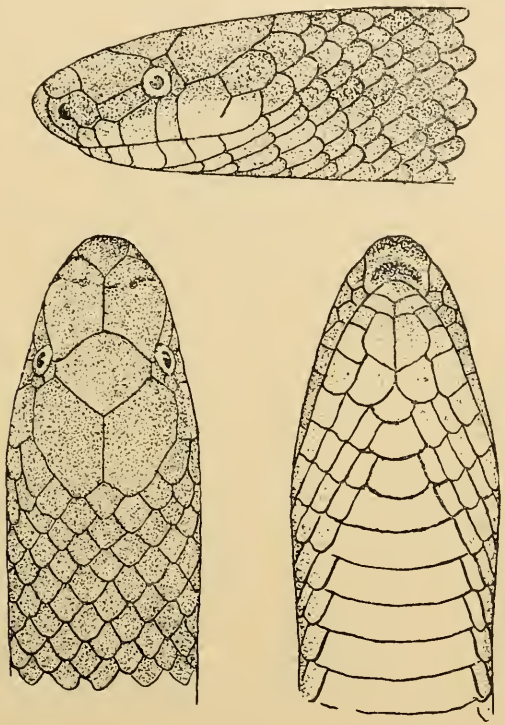
one anterior temporal, elongate; two secondary temporals; six upper labials, in the following order of size, 1, 2, 3, 4, 5, 6; five lower labials; first pair of chinshields touching three labials; second chinshields not typical, as broad as long in contact medially, and touching the first ventral.

Scale formula, 15-15-15; ventrals, 142; anal single; subcaudals, 30 + 1; length of body, 140 mm.; tail, 21 mm.; total, 161 mm.

*Color.* Above, grayish to violet brown, the edges of the scales darker; two outer rows lighter, likewise with darker edges; entire ventral surface creamy white, the pigment encroaching slightly on the paired subcaudals; rostral lightly pigmented; internasals and a stripe in nasal, cream; first two upper labials and the lower two-thirds of the following upper labials, cream; parietals lighter than frontal region.

*Remarks.* The unique specimen was taken under a rock on a hillside about a kilometer north of the village of Cício (sp?) about 17 Km. south of the beginning of the Huetamo Road.

In this general region of Michoacán, two other species of the genus were taken; these were *Geophis dugesi* and *Geophis petersii*. Both of these forms lack the anterior temporal.



TEXT FIG. 2. *Geophis petersii* Bocourt. EHT-HMS, No. 5553; near Pátzcuaro, Michoacán. × 4.

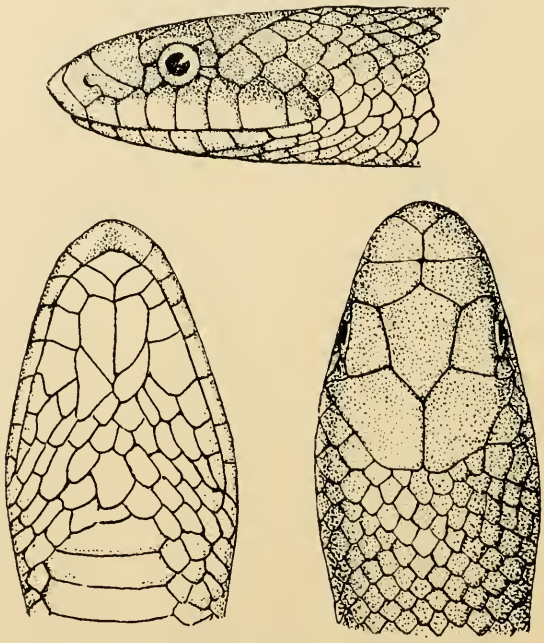
From the four Mexican species recognized in this section of the genus by Smith (Smiths. Misc. Coll., 99. No. 19, February 19, 1941, p. 6) this species differs as follows: from *isthmicus* in lacking transverse bars, the chinshields not touching rostral, six instead of seven upper labials; from *omiltemanus* in lacking the light transverse lines; five instead of seven lower labials, parietal longer than their distance from end of snout; fewer ventrals and subcaudals; from *longiceps* and *latifrontalis* in having an immaculate venter instead of a dark colored venter, and it has fewer ventrals and subcaudals.

A figure of *Geophis petersii* is included for comparison.

*Stenorhina mexicana* (Steindachner)

*Bergenia mexicana* Steindachner Novara-Expedition, Zoölogischer Theil, Bd. I, Reptilien., 1867, pp. 92-93, fig. 3.

I acquired a single specimen of a species of *Stenorhina* at Cuautlapan, Ver., in July, 1940, which appears to be referable to *Bergenia mexicana* Steindachner. This form, which seems unquestionably to be a species of *Stenorhina,* has not been recognized in recent years. The discovery of this specimen suggests strongly that the species should not be referred to *Stenhorina degenhardtii,* as Günther has



TEXT FIG. 3. *Stenorhina mexicana* (Steindachner). EHT-HMS, No. 25168; Cuautlapan, Veracruz. × 3.

done, but should be recognized as a distinct species on the basis of distinctive color pattern, arrangement and character of the teeth, and scale formulae.

*Description.* EHT-HMS, No. 25168. Head not or but slightly distinct from neck; eye small, its diameter minutely greater than its distance from edge of lip, and contained in the distance between eye and tip of snout more than twice; rostral folded back over the tip of snout; part visible above is as wide as one internasal; internasals fused to the nasals; there being a suture running from lower edge of nostril to the first labial (on right side a partial groove between the

prefrontal and nostril, and a groove between the nostril and the rostral), and a groove runs from nostril and terminates in the middle of the upper (internasal) part of the scale; suture between prefrontals shorter than that between internasals, but the scale at its maximum width is a little greater than width of the internasal. Frontal large, a third longer than its distance from end of snout, longer than the parietals, its width more than two-thirds of its length, concave laterally (or very obtusely angulate); parietals as long as wide; loreal absent (fused with the prefrontal, which is in contact with the second labial, rather than with the posterior nasal); a single large preocular and two postoculars, the lower less than half size of the upper; temporals, 1 + 2 + 3; seven upper labials, third and fourth border the eye, sixth largest; seven lower labials, three touching the first chinshields, which are larger than the second pair; three irregular pairs of scales between first ventral and the chinshields; five scales between first ventral and last lower labial.

Scale formula: 23 about back of head, 17, 17, 17; ventral scales, 163; anal divided; subcaudals, 36.

*Dentition.* Maxillary bearing 14 teeth, increasing in size to third, then diminishing from the twelfth to fourteenth; teeth moderately curved; these followed after a short diastema (equal to space of one tooth) by two large, deeply grooved fangs, more than double length of the nearest tooth, and set out of the maxillary tooth row; 11 palatine teeth; 14 pterygoid teeth, the posterior teeth of the series largest and some (11th-14th) showing vague traces of a groove or depression near tip on the outer surface; 17 mandibular teeth, all rather short and thick.

*Color.* Above brownish to violet-gray with a very faint trace of a lighter line along fifth row of scales visible only when submerged. Ventral surface dirty white with indefinite grayish markings along edges of ventrals and trace of a darker irregular median line, more pronounced under tail; chin and lower half of upper lips dirty creamy white.

Total length, 349 mm.; tail, 50 mm.

*Remarks.* This form is distinguishable from *S. lactea* by the absence of the loreal, the smaller eye and the very different coloration; from *quinquelineatus* by the fact that the missing frenal is fused to the prefrontal rather than to the posterior nasal. The color is very different.

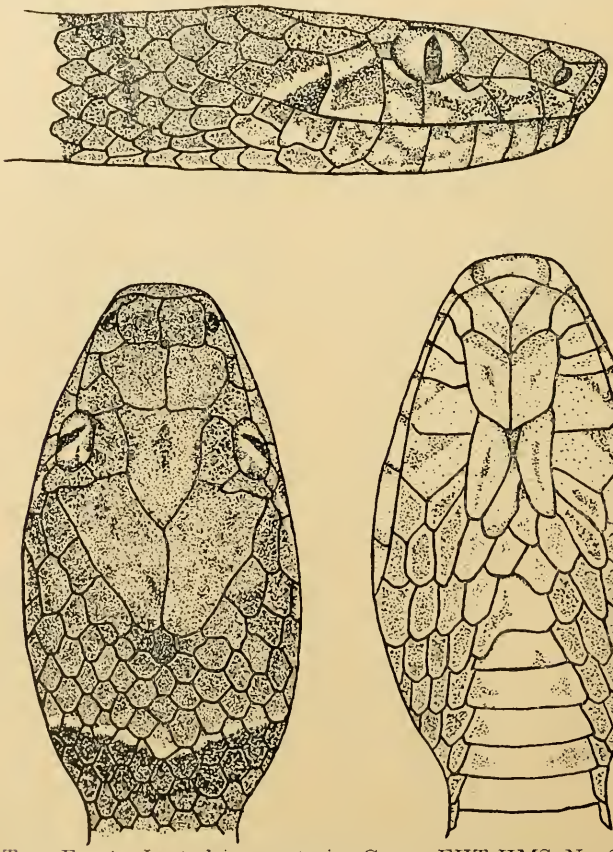
The teeth (*quinquelineatus*): 14 + 2 maxillary teeth, the fangs in line; most of the maxillary teeth show weak grooves, 17 mandibular teeth, most showing lateral grooves; posterior pterygoid teeth

enlarging, some showing traces of grooves; 9 palatine teeth. In *lactea* Cope: 10 palatine teeth; 13 + 2 maxillary teeth, the large fangs practically in line with other teeth; some of the posterior teeth only show a trace of grooving.

The only difference from *Bergenia mexicana*, based on the description and figure, seems to be in the partial fusion of the posterior nasal with the internasal-nasal (a faint groove is evident, where the suture would normally be), and in the fact that the posterior nasal is in contact with the preocular. In other species of the genus these scales are somewhat variable, and I presume that the difference is merely an individual variation.

### *Leptodeira mystacina* Cope

*Leptodeira mystacina* Cope, Proc. Amer. Philos. Soc. XI, 1869, p. 151. "Western region of Mexico, near the Isthmus of Tehuantepec," Taylor, Univ. Kansas Sci. Bull. XXV, 1938 (1939), pp. 325-326.



TEXT FIG. 4. *Leptodeira mystacina* Cope. EHT-HMS, No. 21400; Tierra Colorada, Guerrero. × 3.

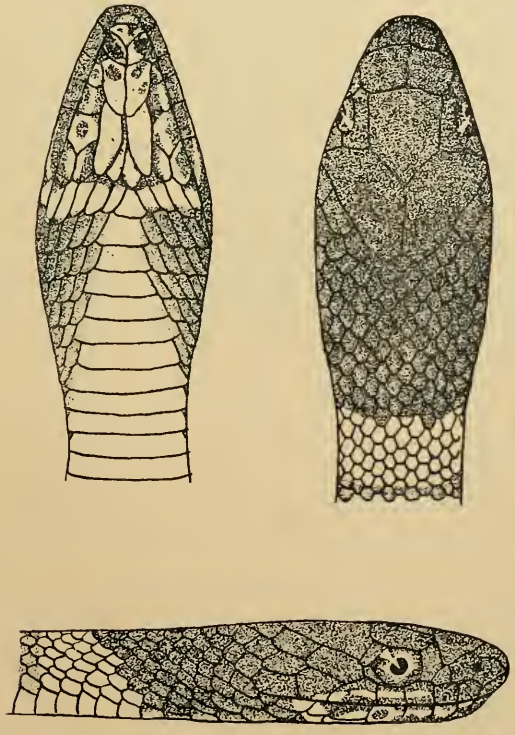
A single specimen of this rare snake (EHT-HMS, No. 21400) was collected near Tierra Colorada, Guerrero, August 31, 1939. The specimen was crawling among climbing plants on the face of a large boulder at night. The specimen agrees very well with the U. S. National Museum specimen mentioned by Taylor *loc. cit.*

There are 10 dark bands on the body; the tail seemingly uniformly dark, since the intervening light spots cannot be discerned. Tail extremely slender. Ventrals, 198; anal divided; subcaudals, 65. The specimen is a female. The head scales are delineated in the accompanying figure.

### *Coniophanes lateritius* Cope

*Coniophanes lateritius* Cope. Proc. Acad. Nat. Sci. Philadelphia, 1861, p. 524, (type locality, Guadalajara, Mexico); Bailey, Papers Mich. Acad. Sci. Arts Letters, XXIV, 1938 (1939), pp. 28-29, fig. 3.

I collected a single specimen of this very rare species (EHT-HMS, No. 5198) near Huajintlán (Km. 133), about 12 miles south of Puente de Ixtla, Morelos. The specimen is a juvenile male. It was found under a rock at the edge of a temporary rain pool.



TEXT FIG. 5. *Coniophanes lateritius* Cope. EHT-HMS, No. 5198; Huajintlán, Morelos. ×5.

With the possible exception of Peters' type of *Tachymenis melanocephala* from an unknown locality, which Bailey regards as a synonym of *Coniophanes lateritius*, this is the only known specimen except the type that has been collected. Since this form has never been figured I append a drawing made by Miss Hazel Watson.

*Thamnophis multimaculatus* (Cope)

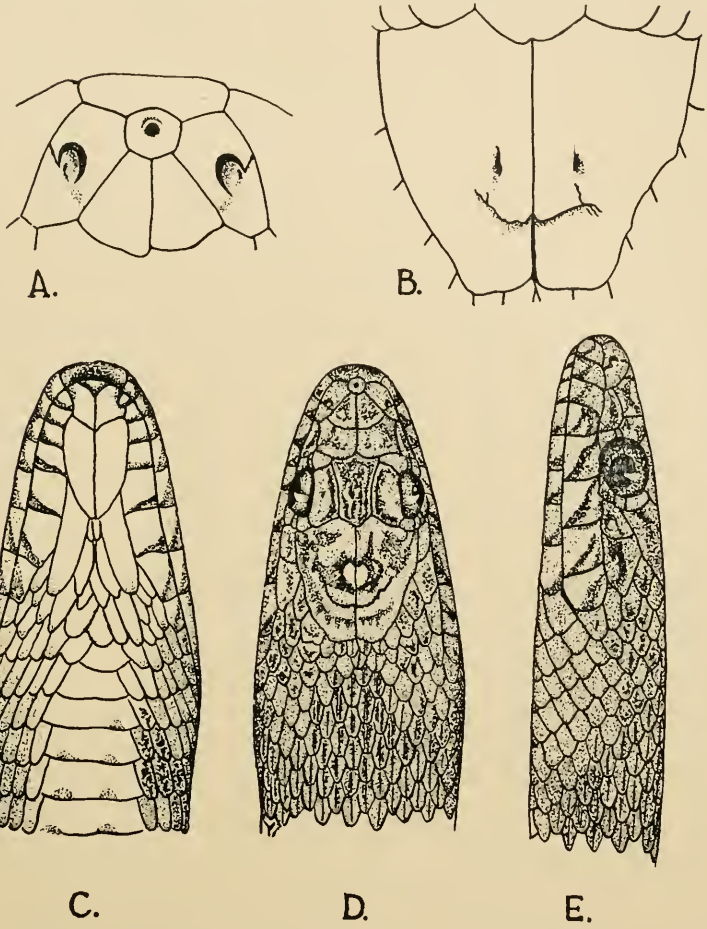
*Atomarchus multimaculatus* Cope, Amer. Nat. 1883, pp. 1300-1301.

*Thamnophis multimaculatus* Taylor and Knobloch, Proc. Biol. Soc. Washington, 53, Oct. 7, 1940, pp. 129-130.

This representative of the fauna of the United States has not been recognized as distinct from *Thamnophis angustirostris* Kennicott. As this form has never been figured, I include with the description a figure of a specimen from Mojárachic, Chihuahua (EHT-HMS, No. 23015). The pitted postrostal scale is not always present, representing a variable element. Similarly pits are not invariably present in the parietals. (Figures drawn by Walter Yost.)

*Description.* Head a little more than twice as long as wide; postrostral circular, separating the nasals, bearing a deep crater-like pit; internasals longer than wide, their posterior width nearly double their anterior width, distinctly longer than the prefrontals; latter scales wider than long, appearing concave anteriorly, convex posteriorly; frontal biconcave laterally, the posterior part rounded, in contact with the upper preocular; supraocular slightly narrower than posterior part of frontal, as wide as or minutely wider than the middle part; parietals longer than wide, longer than frontal, their length equal to their distance from nostril; parietal scales with a break entering the scale from their common suture and curving forward somewhat; just anterior to this, near the edge of paired yellow spots, are two indistinct pits or depressions. Nostril between two nasals, which are fused above nostril (a slight groove is present) and forming a suture below the nostril; loreal elongate, nearly twice as wide as high; three preoculars; upper very large, as wide as high, touching frontal; median rectangular, small, narrow, longer than high; lower quadrangular, higher than long; postoculars, three, on left, four on right side, the lower (one or two) scales lying almost wholly below the eye. Nine upper labials, the fifth only entering orbit; temporals, 1+1+3+4; lower labials, 12, the series forming an angle below eye, the anterior pair of lower labials greatly broadened for the length of their suture; anterior chinshields a little broader, but shorter, than the posterior, which are separated completely; six scales between first widened ventral and the last lower labial.

Scale formula: 26, 21, 21, 19, 19; dorsal scales, save outer row, strongly keeled; outer row smooth anteriorly; dimly keeled posteriorly. Ventrals, 158; anal single; subcaudals 64+.




TEXT FIG. 6. *Thamnophis multimaculatus* (Cope). EHT-HMS No. 23015; Mojárachic, Chihuahua. A, tip of snout (enlarged); B, parietals (enlarged); C, D, E, views of head, × 2.

*Measurements in mm.* Length, 575; tail, 125 (tip missing); length of head, 23; width of head, 11.

*Color.* Ground color above, dull rusty-brown with a double or single median series of narrow transverse blotches, the centers of which are lighter, the borders darker, than the ground color; on each side are two series of spots which are similarly colored; on occiput two larger dark spots, separated by a dim lighter line. Head indis-

tinctly patterned with slightly darker brown color; labials each with a lighter spot, the anterior spots light pearl gray, the posterior ones cream; labial sutures dark; chin and throat cream, the color gradually merging into the gray ventral coloration; an irregular row of darker spots (with lighter centers) on each side of the ventrals; posteriorly on the belly there are other spots; ashy-gray under the tail, the individual spots scarcely discernible.

*Remarks.* I have not been able to determine positively the character of the eye pupil. One is injured and the other somewhat distorted. It appears to be elliptic and somewhat horizontal. When the epidermis is removed the ground color appears pearl-gray, the spots gray-cream bordered by darker gray. A few of the paired dorsal spots are fused and these may cover eight or nine scales transversely. The spots are rarely more than two scale rows wide.

The peritoneum is deep black. There are blackish rings surrounding the papules which border the mandibular tooth series and these rings are connected by a narrow blackish line.

The stomach contained the remains of a small *Rana*.

### *Oxybelis potosiensis* sp. nov.

(Plate VI, figs. 4, 5, 6)

*Type.* EHT-HMS. No. 23614 ♀, collected 38 Km. northwest Ciudad Maiz, San Luis Potosí (Km. 192), September 7, 1940, by E. H. Taylor.

*Diagnosis.* Related to *Oxybelis acuminatus*, but with a less attenuated head; two preoculars; the first pair of labials longer than first chinshields; anterior third of body with black transverse marking, conspicuous when the skin is stretched. No trace of lineation on venter.

*Description of the type.* Eye moderate, its length contained three times in the snout length; rostral projecting above, forming a thick low ridge; internasals elongate, their combined posterior width less than the length of one, in contact laterally with nasal only; prefrontal more than one-third longer than the internasals, angular laterally, forming a canthus rostralis, laterally in contact with the second and third upper labials; frontal narrow, somewhat longer than the supraoculars, but about as wide in widest part, a little longer than prefrontals and shorter than the parietals; parietals followed by a narrow median scale which is flanked laterally by two much enlarged post-parietals; nasal much elongated, distinctly widened at level of nostril and notched below, anterior to nostril by the

curving first labial; two preoculars, lower small, upper large, quadrangular, separated from frontal; loreal wanting; two postoculars, upper largest; temporals large, 1 + 2; 8-9 upper labials, the fourth and fifth, and the fifth and sixth entering orbit; 9-10 lower labials, four touching anterior chinshields; latter about as long as the first labial, much shorter than second pair; second chinshields separated from first ventrals by three paired scales; first ventral separated from last lower labial by 5-6 scales.

Scales smooth save for numerous minute elongate striae, the posterior tips thin and transparent; apical pits wanting; scale formula, 20 (about back of head), 17-17-15; ventrals 184, slightly angulate laterally; anal divided; subcaudals, 164.

The maxillary teeth, 15, are rather large and very strongly curved, followed after a short diastema by two grooved fangs which are scarcely larger than some of the teeth in the middle of the series. One or two of the teeth anterior to the diastema have slight grooves that are scarcely discernible; 10 palatine teeth, the anterior teeth nearly a half larger than posterior; 10 pterygoid, about size of the posterior palatine teeth but less curved; 22 dentary teeth, the anterior largest, curving; a few of these have indistinct lateral depressions or grooves.

*Color.* Above and below, on body generally, ashen to brownish gray. The head similarly colored on top and on sides to near labials; labials cream white, separated from the gray color by a black line; chin and throat (and extending a short distance on venter) cream white, the color gradually assuming the ventral coloration. Eye silvery with an anterior and posterior black spot. On anterior part of body transverse black bars, very distinct when skin is somewhat distended. No trace of ventral light lines.

*Measurements in mm.* Total length, 1,290; tail, 513; head length, 32; greatest width, 10.

*Remarks.* The maxillary teeth of a somewhat larger specimen of *O. acuminatus* differ as follows: The maxillary bone is less heavy, and the teeth are distinctly larger; there are 19 maxillary teeth, the three enlarged posterior fangs very strongly grooved, not separated from other by diastemata; the 8 or 9 preceding teeth with well-defined lateral grooves.

The scale characters of the head differ in the rostrals, being narrower with thinner upper edge; a single preocular; the posttemporal scales smaller; the first pair of labials much shorter than the first

chinshields; three, instead of two, labials enter the orbit; 9 or 10 upper labials.

In *O. microphthalamus* the eye is smaller, the coloration different; 9 upper labials, three entering orbit; the posterior scale rows are 13 only. *O. fulgidus* differs in having a totally different coloration, and in being much larger. Figures are given of three of the forms.

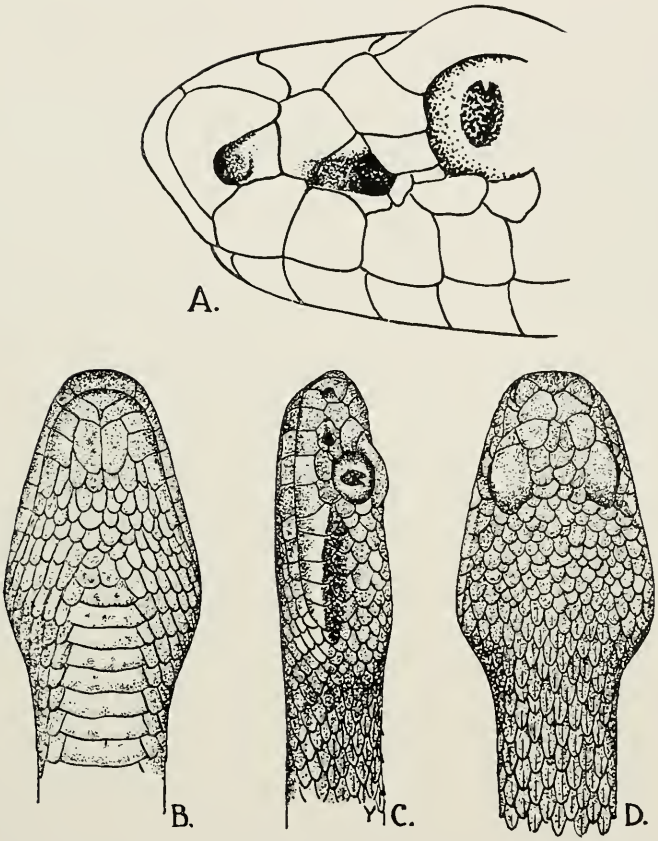
The specimen was discovered in a low tree. It was spread across certain small branches, and remained motionless while I was moving about under the tree, almost within reaching distance of it.

*Crotalus triseriatus gloydi* sp. nov.

*Type.* EHT-HMS, No. 23645, collected on the Cerro San Felipe (elevation 10,000 ft.) near Oaxaca, Oaxaca, Mexico, by Edward H. Taylor.

*Diagnosis.* A "peripheral" form of the *triseriatus* group having the anterior nasal four to five times as large as the posterior, the latter widely separated from the internasal and canthal; loreal touching labials; three preoculars; 6 scales precede supraoculars; head and body uniformly gray to bluish gray with a single median series of indefinite spots.

*Description of the type.* Rostral visible above for a distance half the width of the internasals; latter scales broadly in contact medially, and bordering entire upper edge of anterior nasal contacting the loreal; canthal scales large, touching supraoculars, loreal, and first supraocular laterally; separated by a pair of small scales; frontal region occupied by eight scales in three rows; supraoculars somewhat elevated, large, 1½ times as long as wide; occipital region with small scales, the posterior ones faintly keeled; anterior nasal very large, about 5 times as large as the posterior, which is excluded from internasal and canthal; pit bordered by a single scale anteriorly, posteriorly by second preocular and a second small scale; loreal single, higher than wide, touching labial, both nasals, and upper preocular; three preoculars, the third smallest; lacrimal about size of the second preocular; three postoculars; four temporals bordering labials largest; ten upper labials, the subocular ones separated by a single scale from eye; eleven lower labials; first chinshields large, touched by three labials; second pair very small, separated by a pair of scales. These are separated from first ventral by five pairs of scales; six scales between first ventral and the last labial.




TEXT FIG. 7. *Crotalus triseriatus gloydi* sp. nov. Type. EHT-HMS. No. 23645; Cerro San Felipe, Oaxaca, Oaxaca. A, lateral view of snout, enlarged; B, C, D, views of head. ×2.

Scale formula: 21-21-17; ventrals, 159; caudals, 25. Total length, 416.5 mm.; tail, 35 mm. + rattle, 16.5 mm. = 51.5 mm.

*Color.* Gray or bluish gray to plumbeous, a lighter gray on venter; a cream line borders the upper part of the posterior labials; this bordered by a clearly defined dark line; an indefinite median series of small blotches, separated by a single scale row, consisting of an area slightly lighter than body color enclosed by small black spots on the scales, the whole not more than 2 to 2½ scales wide; there is no evidence of lateral secondary series of spots.

*Remarks.* I have followed Gloyd in considering the various forms of this group as subspecies, although not wholly convinced that this is true where intermediate forms are lacking. When more speci-

mens are known, its status can better be determined. The reduction of the scales on the head suggests a relationship with *omiltemanus* which occurs some 350 kilometers to the west in the mountains of the Sierra Madre del Sur; the lower ventral counts, however, point to the subspecies *anahuacus*, which is found in the high mountains to the north at a distance of some 400 kilometers.

Since the amphibian fauna and the reptilian fauna of this mountain range differ from the faunas of the two preceding regions it is not surprising that this crotalid should prove to be distinctive. The remarkable fact is that it had not been encountered before.

I dedicate the form to Dr. Howard K. Gloyd in recognition of his splendid contributions to the taxonomy of the crotalids.

## PLATE III

### Species of the genus *Thorius* Cope

FIG. 1. *Thorius pulmonaris* Taylor. EHT-HMS, No. 24696; Cerro San Felipe, Oaxaca, Oaxaca, Mexico. Topotype. Total length, 53 mm.

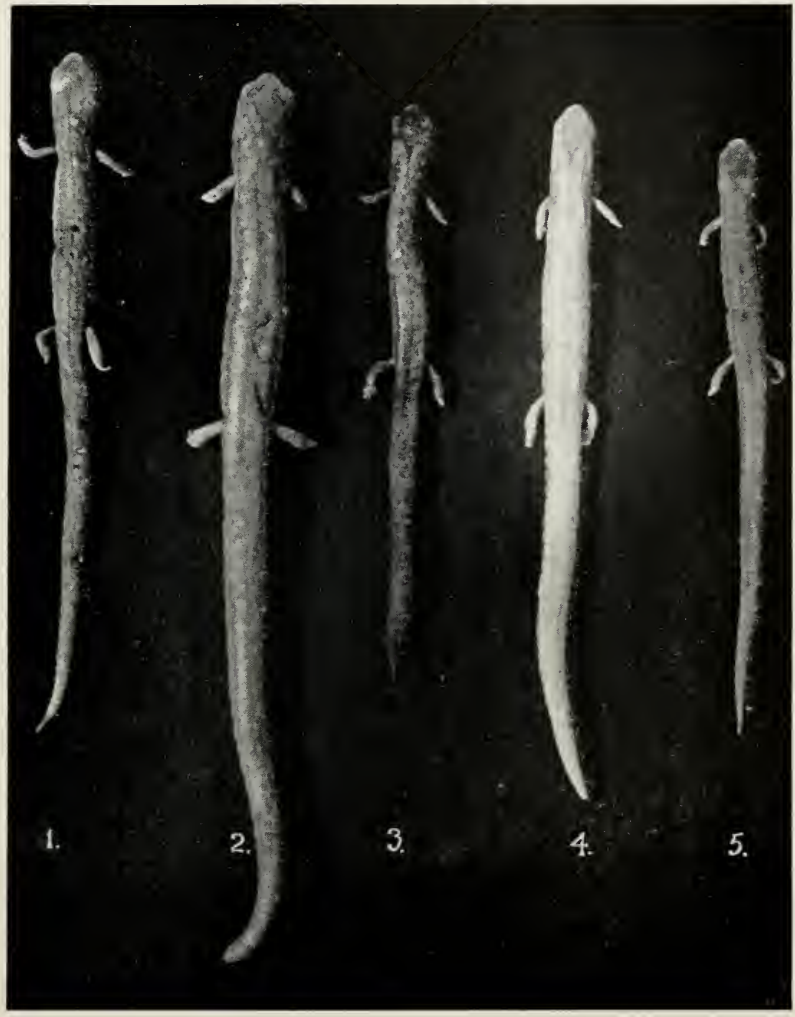
FIG. 2. *Thorius narisovalis* Taylor. EHT-HMS, No. 24991; Cerro San Felipe, Oaxaca, Oaxaca, Mexico. Topotype. Total length, 68 mm.

FIG. 3. *Thorius dubitus* sp. nov. USNM, No. 111001; Acultzingo, Ver. Paratype. Total length, 47.5 mm.

FIG. 4. *Thorius troglodytes* sp. nov. USNM, No. 110999; Acultzingo, Ver. Paratype. Total length, 53 mm.

FIG. 5. *Thorius pennatulus* Cope. EHT-HMS, No. 25453; Cuautlapan, Ver. Total length, 46 mm.

PLATE III



## PLATE IV

### Species of the genus *Eleutherodactylus*

FIG. 1. *Eleutherodactylus occidentalis* nov. nom. for *Borborocoetes mexicanus* (preoccupied). EHT-HMS, No. 18672; 11 miles west of Guadalajara, Jalisco. Length, snout to vent, 41 mm.

FIG. 2. *Eleutherodactylus saltator* Taylor. Type. EHT-HMS, No. 24301; Omilteme, Guerrero. Length, snout to vent, 44 mm.

PLATE IV

## PLATE V

### Mexican Frogs

FIG. 1. *Hyla arboricola* sp. nov. Type. EHT-HMS, No. 24556; six miles east Omilteme, Guerrero, elevation 7,000 feet. Length, snout to vent, 37.5 mm.

FIG. 2. *Eleutherodactylus calcitrans* (Günther). EHT-HMS, No. 24316; Omilteme, Guerrero. Length, snout to vent, 36 mm.

PLATE V

## PLATE VI

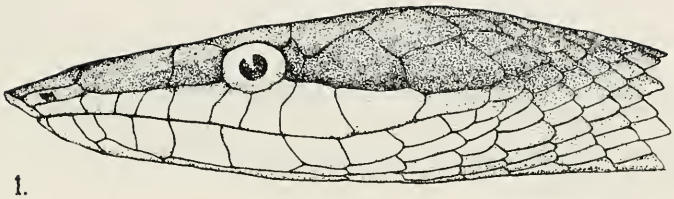
### Species of *Oxybelis*

FIGS. 1, 2, 3. *Oxybelis fulgidus* (Daudin). EHT-HMS, No. 25398; Tres Cruces, near Tehuántepec, Oaxaca. × 2.

FIGS. 4, 5, 6. *Oxybelis potosiensis* sp. nov. Type. EHT-HMS, No. 23614; 38 Km. N. W. Ciudad Maiz, San Luis Potosí. × 2.

FIGS. 7, 8, 9. *Oxybelis acuminatus* (Wied). EHT-HMS, No. 27462; 6 Km. N. Chilpancingo, Guerrero. × 2.

PLATE VI



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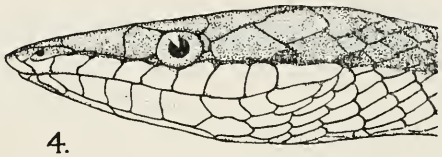

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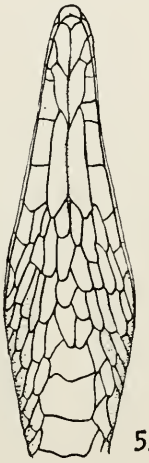

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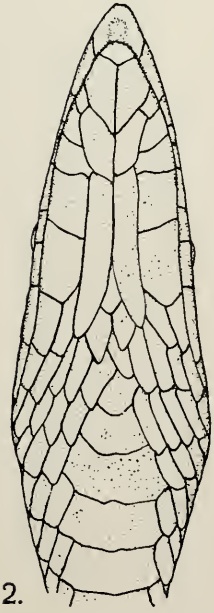

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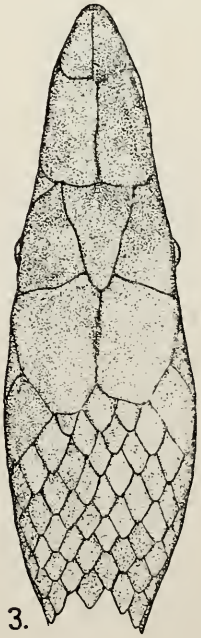

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THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XXVII] NOVEMBER 1, 1941 [No. 8

# New Amphibians from the Hobart M. Smith Mexican Collections

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Department of Zoölogy, University of Kansas

ABSTRACT: This paper contains type descriptions of four new salamanders and two new frogs from Mexico, as follows: Order Caudata, Family Plethodontidae, *Bolitoglossa nigromaculata*, Cuautlapan, Veracruz; *Bolitoglossa occidentalis*, La Esperanza, Chiapas; *Bolitoglossa xolocalcae*, Mount Ovando, Chiapas; *Bolitoglossa nigroflavescens*, Mount Ovando, Chiapas. Order Anura, Family Leptodactylidae, *Eleutherodactylus matudae*, Mount Ovando, Chiapas; *Eleutherodactylus dorsoconcolor*, Tepueyutepec, Veracruz.

A PART of the amphibians from the herpetological collections made in Mexico by Dr. and Mrs. Hobart M. Smith for the United States National Museum, have been placed in my hands for study, by that institution. The collection is very extensive and contains many novelties, certain of which are described herein.

## *Bolitoglossa nigromaculata* sp. nov.

(Text fig. 1, A, B)

*Holotype.* USNM, No. 110635, Cuautlapan, Veracruz, H. M. Smith, collector.

*Paratypes.* USNM, Nos. 110631-110634; 110636-110639, Smith, collector; all topotypes. EHT-HMS, Nos. 24600-24621, Taylor, collector; topotypes.

*Diagnosis.* A medium sized species of the genus, maximum snout to vent length, 56.5 mm.; body generally blackish, the tail lighter, both with small black spots. Tail longer than snout to vent measurement; digits webbed at base; the toes broadly flattened and truncate at tips; terminal phalanx of first finger and toe free; 13 costal

grooves on side; a distinct sublingual fold; teeth on parasphenoid in two series, touching anteriorly; 22-22 vomerine teeth (maximum); about 50-50 maxillary-premaxillary teeth (♀).

*Description of the type.* Adult female. Head about as wide as body or a little narrower; width of head (9 mm.) contained in distance between snout and anterior end of vent, 6.28 times; head length to nuchal fold, (13 mm.) in length, 4.19 times; distance between orbits greater than width of a single eyelid; nostril small, directed forward; a faint trace of a narial swelling on edge of lip; posterior edges of eyelids tucked under a small diagonal fold; dorsal surface of head flat; snout rounding, truncate oval, lacking a canthus; nuchal fold on throat tending to form a broad angle, the apex directed forward; it extends on the side of neck, continues up as a sinuous groove and meets its fellow from opposite side on middorsal line; a vertical groove crosses jaw angle, passes behind eye and can be traced to back of head, but not to middorsal line; a groove from behind eye runs back to the preceding groove; a second groove runs from this back to the nuchal fold; 13 costal grooves, the first and last rather indistinct in type; tail constricted at base; posterior to anus 33 caudal grooves to tip, the tail not obviously compressed; depth of the body about equal to its width; adpressed limbs are separated by 1 to 1½ costal folds; folds formed by hyoid extension terminate at the third costal fold; cloaca lined with curving folds; a small gland visible behind insertion of leg; skin between folds strongly puckered, forming numerous minute folds; pits on skin small.

Limbs well developed; digits very broad, sharply truncate at tips; a slight web extending beyond the metacarpals, to include at least basal portion of the proximal phalanges, and on third finger the web continues as a fringe to base of second phalanx; order of size in fingers, 1, 2 = 4, 3; phalangeal formula, 1, 2, 3, 2; toes in following order of size, 1, 2, 5, 3 = 4 (right) and 1, 2, 5, 4, 3 (left); phalangeal formula, 1, 2, 3, 3, 2; on foot, a web includes the proximal phalanges, but is slightly excised between these phalanges; pads at tips of digits not prominent. Tongue boletoid, relatively small, with a semicircular, sublingual fold; maxillary-premaxillary teeth well developed, rather heavy, 48-49 (♀); vomerine tooth series, 20-21, very long, curving back, extending about one-third of their length beyond (lateral to) the choanae, separated medially by a space about equal to the space between two teeth, and separated from the parasphenoid teeth by twice that distance; parasphenoid teeth in two rather narrow diagonal series widely separated posteriorly, but contiguous anteriorly; choanae moderately large.

*Color.* Above on body and tail gray-black or dark lavender, nearly uniform, a few shades lighter on ventral surfaces; when submerged in water or alcohol, distinct black spots are to be seen scattered over dorsal and lateral surfaces of body and tail; a light cream spot on lower eyelid; undersurface of feet and hands dark, the indistinct pads at tips slightly lighter; an indistinct, arrow-shaped, light spot at base of the distal phalanges.

Measurements in mm. of *Bolitoglossa nigromaculata* sp. nov.:

| Number | Type 110635 | 110632 | 110631 | EHT-HMS 24620 |
|---|---|---|---|---|
| Sex | ♀ | ♀ | ♀ | ♀ |
| Snout to anterior end of vent | 56.5 | 52.4 | 51.2 | 54.4 |
| Anterior end of vent to tip of tail | 65.0 | 66.0 | 66.0 | 74.0 |
| Snout to eye | 3.1 | 3.0 | 2.9 | 3.1 |
| Snout to nuchal fold | 13.0 | 11.9 | 11.8 | 12.1 |
| Width of head | 9.0 | 8.3 | 8.4 | 8.7 |
| Head width in head-body length | 6.28 | 6.3 | 6.2 | 6.2 |
| Axilla to groin | 35.0 | 32.2 | 29.8 | 35.0 |
| Arm | 15.0 | 13.4 | 15.0 | 15.0 |
| Leg | 17.5 | 15.2 | 16.0 | 16.0 |
| Limbs separated by folds | 1½–2 | 1½–1 | 1½–1 | 2–2 |
| Maxillary-premaxillary teeth | 48–49 | 48–49 | 47–47 | 54–54 |
| Vomerine teeth | 20–21 | 17–17 | 19–15 | 19–21 |
| Mandibular teeth | 49–48 | 53–50 | 52–50 | 52–51 |

*Variation.* The series of paratypes show considerable variation in coloration. Practically all the smaller specimens have the general color grayish, gray brown, or lavender, the tail generally being grayish cream or pinkish cream, often with lighter silvery flecks; the ventral surface usually still lighter than the dorsum; silvery flecks may be present on the chin, sometimes on head and body; the venters are usually lighter than in type.

The black spots are very irregularly distributed, their distinctness depending on the depth of the ground color; limbs are often spotted and are lighter or darker, depending largely on the color of the body. In several of the younger specimens the adpressed limbs may touch, usually so in males; old males may have the four premaxillary teeth piercing the lip; in younger males they are enlarged, but do not pierce the lip. The number of teeth is less in younger specimens. The cloaca of the male has fine papillae; the sublingual fold is very far forward and has an extensive free edge; a submental gland is present in males, but it is relatively indistinct; the subnarial swellings are larger in males than in females, but much smaller than in *cephalica* or *leprosa*.

*Remarks.* Some years ago in studying the type and paratypes of *Oedipus leprosus* in the National Museum I noted that four species

A B C

TEXT FIG. 1. A and B, *Bolitoglossa nigromaculata* sp. nov., A. type, USNM, No. 110635, Cuautlapan, Veracruz, Mexico, adult female with eggs, 121.5 mm.; B. Paratype, USNM, No. 110632 ♀, 118.4 mm., same locality. C. *Bolitoglossa occidentalis*, Paratype, Finca Juarez, Chiapas, Mexico. EHT-HMS, No. 24049, 58 mm.

were represented, and in a paper (Taylor, Univ. Kansas Sci. Bull., Vol. XXV, 1938 [July 10, 1939], p. 274) I mention that two (now USNM, No. 6340) are probably representatives of a new species. It seems certain that these two specimens belong in the species here described, since they agree in practically all details.

The species is a terrestrial form and appears to be related to *cephalica* and *leprosa*. From the former it differs in the propor-

tionally longer tail, the larger series of maxillary-premaxillary teeth, and the reduced size of pits in skin. The shape of the digits and the coloration are different.

From *leprosa* it differs in having the digits truncate, widened, and more webbed at base; the vomerine and the maxillary-premaxillary tooth series are larger; the limbs are longer; the tail longer and more attenuated; the choanae are larger.

*Bolitoglossa occidentalis* sp. nov.

(Text fig. 1, C)

*Type.* USNM, No. 111085 ♀, collected at La Esperanza, Chiapas, Mexico, elevation 500 feet, April 28, 1940, by Dr. and Mrs. Hobart M. Smith.

*Paratypes.* USNM, Nos. 111068-111084; 111086-111093; EHT-HMS, Nos. 27176-27180, topotypes; EHT-HMS, No. 24049, Finca Juarez, Chiapas, elevation 2,500 feet; EHT-HMS, No. 26561, El Porvenir, Guatemala; Field Museum Nos. 20330, five specimens; 20397, 20399, 20712, 20713; 20760, four specimens; El Porvenir, Guatemala.

*Diagnosis.* A relative of *Bolitoglossa rufescens,* agreeing in the extremely inflated nasal region, absence of folds under tongue, fully palmate hands and feet, but differing somewhat in coloration and in the presence of a series of maxillary teeth.

*Description of the type.* Body short, limbs strong; head wider than body, rather flat; the eye (2.2 mm.) nearly equals length of snout (2.3 mm.); nostrils small with distinct subnarial swellings (smaller than those in male); eyelid rather narrow (1.5 mm.), smaller than interorbital width (2.1 mm.); width of head (5.3 mm.) contained in distance from snout to posterior end of vent (31 mm.) 5.9 times; head length to nuchal fold contained in the same distance 3.9 times. Tongue free without trace of a free sublingual fold; vomerine teeth 6-6 slightly elevated, reaching inner level of choanae, separated medially; parasphenoid teeth forming a single group, narrowed anteriorly, widened posteriorly, separated from vomerine teeth by a distance greater than that between the vomerine series; choanae small, rounded, a minute pit between choana; maxillary bone forms a broad platform, seen from below, bearing a series of five teeth on each side, which are widely separated from the three premaxillary teeth (which in male may be reduced to two teeth which pierce the lip); about 25 very small mandibular teeth present.

Skin, on head with almost obsolete pitting; on neck and back very

smooth; skin on sides wrinkled and corrugated between costal grooves, of which there are 13, but are often very indistinct, not continuing on ventral surface; posterior end of eyelids terminate under a slight diagonal fold; a groove from behind eye runs back and down, becoming continuous with a groove that crosses the angle of jaws; gular grooves pass a short distance up on sides of neck; extension of hyoid cartilage (epibranchial) makes a strong elevation in front of and above arm insertion, extending to about the third costal fold; hands and feet completely palmate, the tip of third finger and third toe free, the "web" slightly emarginate between digits; adpressed limbs separated by about 2 costal folds; cloacal opening with folded walls (papillate in males); tail with the lateral grooves obsolete; shorter than head and body.

*Color.* Dorsal coloration grayish to dull brownish cream with darker lavender brown markings which arise above each eye, and cross on the neck; the latter half of body is variously streaked; tail likewise streaked above; sides of head, body and tail darker, about color of dorsal markings.

Ventral surfaces light, with some scattering of pigment, sometimes leaving light flecks or tiny blotches.

*Measurements of type in mm.* No. 111085; sex, ♀; snout to vent, 31; width of head, 5.3; head to gular fold, 8; snout to arm, 8.8; axilla to groin, 16.2; snout to posterior end of vent, 31; tail, 17; arm, 8; leg, 7.5.

*Variation.* The color pattern varies considerably, but the lines arising above the eyes and crossing on neck are usually discernible; the sides of the dorsal part of the neck and the base of the tail are usually lighter than the remainder of dorsal surface. Many specimens have a darker venter with the lighter flecks distinct. In males the subnarial swelling is greater and usually the premaxillary teeth pierce the lip. The maxillary teeth vary between five and eight on each side, sometimes fewer on the very young.

The series of specimens from El Porvenir, San Marcos, Guatemala, collected by Mr. Karl P. Schmidt and examined through his kindness, are a little larger. Of the thirteen specimens from this locality, ten exceed 35 mm. in length from snout to posterior end of vent; the largest specimen, a male being 39 mm.; the largest female is 38.1 mm. and is filled with nearly ripe eggs.

The statement in Dunn (Plethodontidae, p. 48) suggests, perhaps not intentionally, that giving birth to young is the normal condition in the genus "Oedipus" = [*Bolitoglossa*, etc.]. In the large series

of Mexican species I have found no evidence in any case of oviparity. On the other hand, numerous clutches of eggs found in decaying logs, and under logs and rocks, in bromeliads, etc., point to the fact that most, if not all, Mexican forms are typically oviparous. Dunn states explicitly that *adspersus* produces living young (p. 16).

The variation of the teeth in this group is considerable. In two of the youngest specimens (24, 29 mm.) I did not find trace of the maxillary or premaxillary teeth. In one adult, one of four bearing the number Field 20330, I was unable to determine positively the presence of the maxillary teeth, although premaxillary teeth are present. In the others there were usually two premaxillary teeth, which in the males pierced the lips, the skin forming a papilla at their base. Maxillary teeth were variable in number. The following formulae were found: 5-7, 4-7, 8-9, 2-1, 3-2, 2-0, 10-11, 5-2, 4-2, 3-3; for vomerine teeth the following were counted: 7-8, 3-4, 6-7, 5-6, 9-11, 7-6, 5-5, 7-9, 6-8, 5-6. The mandibular series was large, varying between 27 and 39 on half of the lower jaw. The number of teeth in females did not exceed those in certain males. As the smaller numbers of maxillary teeth occurred in old as well as young specimens, it is possible that some of the teeth had been lost and not replaced.

*Skull.* While no thorough study has been made of the skull the following facts have been noticed. The frontal and parietals appear to be well ossified and maintain their shape when disarticulated; the nasals are not or but slightly ossified and extend over the large nasal capsules; the premaxillary is a short, compact element without lateral projections and forming a rather loose junction with maxilla and is, at least, partially ossified; the processes which arise from it are minute, threadlike cartilages. They touch the frontals, but lie deeply buried between the nasal capsules; the lower alveolar edge of the maxilla has a broad surface. The mandible is not well ossified, tending to curl up somewhat when dried.

*Relationships.* The closest relative is *B. rufescens* (Cope) which it resembles in most characters save the presence of maxillary teeth. The same skull characters obtain as far as observed.

It is possible that *Bolitoglossa colonnea* (Dunn) is also a member of this species group. It has a somewhat longer tail, a fold across the head, but agrees in numerous other characters. *Bolitoglossa striatula* (Noble) may be related also, but since I have not examined the types of either of the two latter species I cannot be certain.

When the skeletal characters of this group are better known it will probably be necessary to elevate it to the rank of a genus.

*Bolitoglossa xolocalcae* sp. nov.

(Plate VII; Plate IX, figs. 7-8)

*Type.* USNM, No. 111371. Collected at Cerro Ovando, Chiapas, Mexico, between 6,800-8,000 feet elevation, April 16, 1940, by Dr. and Mrs. Hobart M. Smith.

*Paratypes.* USNM, Nos. 111372-111470 and EHT-HMS, Nos. 25311-25341; 26749-26783; 27264-27271. All same data.

*Diagnosis.* A small bromeliad salamander with head and body flattened, the tail somewhat quadrangular in cross section, a little longer than head and body; nostril minute; hands and feet large, first finger and toe involved in web, the other digits with the distal phalanx and part of the adjoining phalanx free; parasphenoid teeth in two series; vomerine teeth numerous, large series of teeth in both jaws; a whitish bar across head between eyes.

*Description of the type.* Head distinctly wider than body, greatly flattened, without trace of a canthus rostralis; snout, somewhat truncate, but oval in profile; eye not strongly raised, its length (2 mm.) equal to its distance from the nostril, shorter than snout (2.45 mm.); groove below eye terminates anterior to posterior level of eye; eyelids terminate posteriorly under a small diagonal fold; line of mouth straight, diagonal to back of eye, then curving slightly; subnarial swelling very small; distinct upper extension of the hyoid forms a strongly elevated ridge on side of neck and above arm, terminating at about the level of second costal fold and from this an indistinct dorso-lateral fold continues to groin.

Tongue free with a somewhat thick, sublingual fold (prelingual); maxillary-premaxillary teeth about 36-36, with a similar number on the mandible; vomerine teeth in a somewhat irregular series, about 13-13 extending beyond outer level of the small elongate-oval choanae; parasphenoid teeth in two series, narrowed anteriorly, widened posteriorly and notched behind, widely separated from the vomerine series.

Skin above, especially on head, pitted or corrugated, as seen under a lens, and forming small, roughened, somewhat elevated areas, especially noticeable on eyelids, which are about the width of the interorbital space; a vertical groove which crosses jaw angle can be traced to the dorsal level of head; longitudinal groove behind eye obsolete (in some specimens it is distinct and continues to gular groove); an ample gular fold, the grooves emerging from its ends continue indistinctly to the median dorsal line; 11 distinct costal grooves; the inguinal and axillary grooves apparently absent, the

grooves extending across abdomen; a small glandular spot behind insertion of femur; tail slender, strongly attenuated, not or but slightly constricted at base, and apparently not fragile (practically all the paratypes have the tails intact); limbs strong, the hands and feet large, the adpressed limbs separated by one costal fold; first finger and toe included in the web; digits broad, truncate, with a terminal subdigital pad about as broad as long; greater part of two distal phalanges free of web; about thirty caudal grooves; an indistinct skin fold from jaw angle to the end of the gular fold.

*Color.* Above mottled brownish-lavender with a median faun-colored spot on dorsal surface of neck; a transverse cream bar crosses head and eyelids; snout surface cream with brownish flecks; a light, irregular area at base of tail, above; the dorsal surface of the tail lighter than the body; color on sides becomes gradually lighter and merges with the dirty cream color of the ventral surfaces, on which the pigment is equally distributed; limbs generally lighter than body, with an indefinite darker area at knee and elbow, enclosing a lighter area.

*Measurements in mm.* Snout to posterior end of vent, 36.7; tail, 39.5; total length, 56.2; width of head, 6; length of head to gular fold, 8.7; snout to forearm, 12; axilla to groin, 13.

*Variation.* There are two other distinctive color patterns present. A small number of specimens have a pair of dorso-lateral cream lines beginning on the eyelid, continuing back and often divided by a narrow, black line posteriorly; posteriorly they are confluent with the cream color, perhaps pinkish in life, which colors the dorsal surface of the tail; on sides below the light line is a distinct black line, gradually becoming lighter on its lower edge; the light color of the snout is scarcely discernible and the light bar may be largely obscured.

Another color variety has the back and tail pinkish cream with a pair of black dots on neck and a well-defined blackish triangle following the indistinct head bar; the snout is darker than body.

The bulk of the specimens resemble the type in markings, although there are often chevronlike markings in black on the back and tail; most of the specimens have the black triangular head marking which can barely be discerned in the type. Males have the body a little shorter and the adpressed limbs often touch or overlap slightly; the snout is a trifle longer and the head perhaps a little more flattened than in the female. The submental gland is more or less visible externally. The subnarial swellings are more prominent and the cloacal walls are papillate.

The premaxillary teeth are much enlarged, with three or four of them piercing the lip; the maxillary and mandibular teeth differ but little in general character.

In a hasty examination of the skull, one notes that the superficial bones of the brain case are fairly well ossified, while those of the nasal capsules are largely cartilage. Maxillaries and mandibles well ossified and firm while the premaxilla appears to be very flexible, its shape is that of this element in other members of the group, but its contact with the maxillary is slight.

All these specimens were obtained in bromelias.

*Relationships.* The probability is that this is an aberrant member of the *chiroptera* group. The flattened head is obviously an adaptation to the habitat in bromelias and is a characteristic of the recently described *Bolitoglossa arborea*. Like *chiroptera* the young have enlarged nostrils.

The species name is derived from Xolocalco, the Indian name of the Cerro Ovando.

### *Bolitoglossa nigroflavescens* sp. nov.

(Plate VIII; Plate IX, figs. 9-10)

*Type.* USNM, No. 111169 ♂; collected on Cerro Ovando, at an elevation between 5,000 to 6,000 feet, April 16, 1940, by Dr. and Mrs. Hobart M. Smith.

*Paratypes.* USNM, Nos. 111153-111168 and 111170-111192; EHT-HMS, Nos. 26784-26799. Topotypes; same data as type.

*Diagnosis.* A rather large species; body somewhat flattened, the head broader than body; maximum snout to vent measurement, 57 mm.; tail, 51 mm.; two distal phalanges free from web, except first which is free only at tip of digit; digits broad, truncate; no sublingual fold; 11 costal folds; premaxillary teeth of male very greatly enlarged, piercing the lip; above grayish-black, yellowish on sides; or dark with large cream or orange spots above (greenish in life).

*Description of the type.* Head wider than body; lacking a canthus rostralis, flattened, the musculature of neck not visible; eye rather small (3.2 mm.), shorter than snout (3.8 mm.); nostril minute, the groove passing back from nostril and forming a right angle where the groove turns down to the much inflated subnarial swelling; end of snout slightly rounding; width of eyelids much less than interorbital width; line of the mouth straight from narial swelling to below posterior corner of the eye where it makes a slight angle and continues back, curving very slightly; the posterior ends of eyelids are tucked under a diagonal fold.

Maxillary teeth few, moderately large, about 20-20 (counting missing teeth, actually 17-14); 2 premaxillary teeth; about 38-38 mandibular teeth which are smaller than the maxillary; vomerine teeth about 10-10 (counting absent teeth) in two irregular curving series extending beyond outer level of choanae, separated medially by a distance equal to width of a choana; parasphenoid teeth large, in a single group, forming a triangle, not notched behind, and separated from the vomerine series by a distance twice as great as that between the vomerine series.

Skin with shallow pits; a groove crosses the throat which passes up across the jaw angle, not reaching dorsal surface of head; gular fold well defined, the grooves from its sides not reaching the dorsal surface of the neck; a shallow groove from the back of eye curves to meet the first vertical groove; no continuation of this groove to the gular grooves; 11 costal folds, those of axilla and groin lacking, although a depression or slight beginning of a groove is visible above anterior edge of the insertion of the femur; the upper posterior projection of the hyoid forms two strong ridges which extend to posterior level of arm insertion or a little farther; sides more or less puckered with longitudinal folds between the costal grooves; some suggestion of a longitudinal lateral fold above the costal folds; submental gland very large, biconvex, transversely placed. The tail has a slight basal constriction; limbs well developed, when adpressed the digits touch; hands and feet very large, the digits spread, the width of each greater than their distance to elbow or knee; inner toe and finger with the large rounding tip free; middle fingers and toes flattened, truncate, with two phalanges free, others with 1½ to 1⅘ free. Males with cloacal walls papillate. A fold from jaw to gular fold; a glandular area behind femur.

*Color.* Gray to purplish-black above, the tail darker than body; sides dull yellowish cream; the venter and under surface of the limbs dirty yellowish cream; under side of tail darker than venter; upper surface of limbs lighter than dorsum save for areas at knee and elbow.

*Measurements in mm.* Snout to posterior end of vent, 55; tail, 51; width of head, 9.2; length of head to gular fold, 14.3; snout to arm, 17; axilla to groin, 28; arm, 15.2; leg, 15; spread of hand, 7.2.

*Variation.* Females have a somewhat longer axilla to groin measurement, the limbs separated occasionally by 1½-1 costal fold; the lips of the cloaca are folded. Numerous specimens representing both sexes have a greater or lesser number of scattered, irregular

cream or orange spots, most frequently present on the shoulder region, along the dorsolateral region or the tail. Occasionally they are on tail and not on body.

The number of teeth in the female is greater than in the male; about 30-30 for the maxillary, 4 premaxillary, 15-15 vomerine, mandibular 40-40; there is less variation in the size of teeth in the female.

*Relationship.* The relationship is with *Bolitoglossa englehardti* and *macrinii;* superficially they may resemble *B. flavimembris.*

From *englehardti* it differs in being more robust, having a shorter, thicker, tail, narrower head, the vomerine teeth extending beyond choanae, and the parasphenoid teeth in a single group (double in *englehardti*), the digits have only the distal phalanges free. From *macrinii* it differs in having a much shorter axilla to groin measurement, there being four or more costal folds between the adpressed limbs, in that species.

*Remarks.* The large series of specimens were obtained on the mountain chiefly in the region between 6,000-6,800 feet. All were taken in bromelias; at this elevation they were replaced by the smaller bromeliad salamander *Bolitoglossa xolocalcae.*

*Eleutherodactylus dorsoconcolor* sp. nov.

(Plate X)

*Type.* USNM, No. 110619 ♀, Tequeyutepec, Veracruz, 5,600 feet elevation, H. M. Smith, collector.

*Paratypes.* USNM, Nos. 110615-110618, EHT-HMS, No. 24321. Same locality and collector.

*Diagnosis.* A member of the *rhodopis* group. A dorsolateral folds from corners of eyes, converging slightly, run to lumber region; a second fold above the tympanum to midway on side; ventral disk more or less granular posteriorly; male less than half the bulk of the female, with vocal sacs. Tympanum as large as eye; smaller and proportionally higher in females. Area between folds usually clay, brown, or brown-orange.

*Description of the type.* Head longer than broad (15.9 mm. to 14.5 mm.); interorbital distance much wider than eyelid (5 mm. to 3 mm.); diameter of tympanum less than diameter of eye (3.2 mm. to 4.4 mm.) (in males nearly equal); eye to nostril, 3.8 mm.; nostril to tip of snout, 2.4 mm.; distance between nostrils, equal to their distance from eye; length of snout, 6.1 mm.; canthus rostralis rounding; lores sloping somewhat to lip and slightly concave behind nostril; dorsolateral folds beginning at the corner of the eye, converge

somewhat toward the dorsal lumbar region, where they terminate at a slightly enlarged tubercle, the end turning in; this followed by two or three pairs of enlarged tubercles; a fold from above tympanum runs back along the sides, breaking up into an irregular series of tubercles, which can be traced more or less to near the groin; head and occipital region smooth; body granular posteriorly; sides strongly granular or pustular; chin smooth; ventral disk distinct, its outer and posterior parts distinctly granular; ventral surface of femurs largely granular; dorsal surface of hind limb rough, some of the pustules arranged in a slightly diagonal fashion; a small, inconspicuous gland, only a little larger than surrounding tubercles, present in the axillary region, the lumbar gland discernible as only a few flecks in the transparent skin with a few scattered pores on the surface; a strong posttympanic fold with a small glandular tubercle lying between tympanum and arm; tongue oval to subcircular, apparently not nicked behind; vomerine teeth in two raised areas separated from each other by a distance equal to their distance from the choanae, lying between, but much posterior to, the level of choanae; (male with vocal sacs, the openings of which extending somewhat farther forward than usual).

Limbs long, the wrist extending beyond snout; the tibiotarsal articulation reaching beyond tip of snout by a distance equal nearly to half the length of the snout; subarticular tubercles very large; median palmar tubercle largest and touching smaller outer tubercle; first finger distinctly longer than second; tissue at base of first and second fingers is granular, thickened, suggestive of a web remnant; an indistinct row of tubercles on under surface of forearm; subarticular tubercles of feet large, salient with supernumerary tubercles on sole; inner metatarsal tubercle large, generally oval, about double the size of the outer, its length in first toe less than two times; an elongate tubercle on the inner edge of the tarsus, with a slight ridge from its distal end; a slight ridge following outer edge of fifth finger reaches the tarsus and continues to heel as an indistinct series of elongated tubercles on outer edge of tarsus; a slight trace of a web evident between the first three toes; toes with very slight lateral ridges, the tips dilated somewhat, without or with only an indistinct transverse groove (unless slightly desiccated).

*Coloration.* Above uniform orange brown, the head slightly darker and a pair of irregular dark spots in interorbital region, more or less connected with a somewhat darker median area behind them; outer edge of the dorsolateral folds black; the sides dark, growing

lighter towards venter; groin usually not pigmented; canthus with a black line; lores dark brown; lip barred with dark spots, separated by lighter areas.

*Measurements of Eleutherodactylus dorsoconcolor* sp. nov. (in mm.)

| Numbers | 110619 | 24321 | 110618 | 110616 |
|---|---|---|---|---|
| Sex | ♀ | ♂ | ♂ | ♂ |
| Snout to vent | 39.2 | 27.2 | 25.2 | 25.3 |
| Width of head | 15.6 | 11.1 | 10.1 | 10.0 |
| Length of head | 16.2 | 11.5 | 10.4 | 10.0 |
| Diameter of eye | 4.4 | 3.3 | 3.2 | 3.0 |
| Diameter of tympanum | 3.2 | 3.3 | 3.0 | 2.9 |
| Eye to nostril | 3.8 | 3.3 | 3.1 | 3.0 |
| Length of snout | 6.1 | 4.5 | 4.5 | 4.3 |
| Tympanum to eye | 1.8 | 1.0 | 1.0 | 1.0 |
| Arm | 22.0 | 14.8 | 14.8 | 16.1 |
| Leg | 73.5 | 48.8 | 47.2 | 46.0 |
| Tibia | 23.0 | 16.1 | 16.0 | 15.6 |
| Foot | 33.3 | 22.3 | 20.8 | 23.2 |

*Variation.* The variation in color or the dorsum varies from light putty-color through gray-brown, dark-brown to orange-brown. In one of the males the limbs and sides are so dark as to obscure other markings. Males have more pigment on the venter; especially on chin, thighs, and sides of breast. One of the small specimens No. 110618 (snout to vent 19 mm.) has a bluish white median line.

In all, the first finger is longer than second; the tarsal tubercle present; the lumbo-inguinal gland and the axillary gland are present in all, the glands being more distinct in males. Several of the specimens have a hair-fine medial ridge, and the dorsal granules may form dim lines.

*Remarks.* The markings on this species are strongly reminiscent of those of *Microbatrachylus minimus* Taylor.

The specimens were taken on a long grassy slope (pasture between two wooded ridges). It was drizzling rain and they were hopping about.

Related to *dunni* and *beatae*, but differing strongly in markings.

### *Eleutherodactylus matudai* sp. nov.

(Plate XI)

*Type.* USNM, No. 110626 ♀ Mt. Ovando, Chiapas, April 16, 1940; Dr. and Mrs. Hobart M. Smith, collectors.

*Paratypes.* USNM, Nos. 110620-110625; 110627-110630; and EHT-HMS, 24353, 24354. Same data as type.

*Diagnosis.* A medium sized species (maximum known size female, 40 mm.; males, 28 mm.), heavily rugose with minute pearly-topped tubercules, and a pair of sinuous dorsal folds widely separated on

back; canthus rostralis sharp, the edges slightly raised; inguinal gland small, distinct; diameter of tympanum little more than a half of the eye in females; more than four-fifths in males; first finger equal or shorter than second; ventral disk not strongly defined; tongue nicked behind; vomerine teeth well developed; some pigment in mouth and under tongue; digits somewhat dilated; no vocal sac in male.

*Description of the type.* Body wider than head; length of head (14.5 mm.) a little less than width (17.3 mm.); tympanum somewhat deeply sunk, its diameter (3 mm.) a little more than half eye (diameter, 5.5 mm.); distance between nostrils (4.1 mm.) a little greater than distance between eye and nostril (3.9 mm.); width of eyelid (3.6 mm.) greater than interorbital distance (3.2 mm.); length of snout, 6.1 mm.; eye to tip of snout, 7 mm.; distance of tympanum from eye (in female) equal to diameter of the former; canthus rostralis sharp, the edges somewhat raised; snout pointed, the region about nostrils rather swollen; lores rather vertical near canthus, then sloping rather broadly; a pair of dorsolateral folds start slightly back of eyelid above corner of eye and curve inward on shoulders, where they are separated by a distance of 7.5 mm.; from this point they curve and again approach, in middle of body separated by 5 mm.; from this point they curve out, and approach on rump where they are separated by 8 mm.; a well-defined supratympanic fold begins on edge of eyelid and continues to above arm, terminating in a glandular swelling; a short fold runs back above arm, and other ill-defined folds are discernible on sides and rump region; ventral disk is not clearly defined save the fold across breast; inguinal gland distinct, small, yellow; axillary gland small, indistinct, difficult to discern; chin and breast indistinctly granular; venter partially granular or areolate with transverse wrinkles or folds near median line; ventral and posterior surfaces of femurs large, areolate.

Tongue free for one-third to one-fourth of its length, subcircular, apparently slightly emarginate (somewhat distorted; paratypes show tongue to be nicked); vomerine teeth well developed, separated by a distance equal to less than half width of one group, behind, but within inner level of choanae; latter large, about equal in extent to a patch of vomerine teeth; no minute papillae evident on mouth membranes; interorbital palatal region strongly grooved.

Arms brought forward, the wrist reaches beyond snout; first finger equal to second; pads widened a little and thickened with a trans-

verse groove, usually distinct; subarticular tubercles low, flattened, rather indistinct, as are the supernumerary tubercles; median palmar tubercle flat, large; outer obsolete; inner somewhat more than half size of middle; indistinct row of tubercles on under surface of forearm; leg long, the heel reaching beyond tip of snout a distance equal to the length of snout; foot with a mere trace of a web, with narrow dermal fringes on the toes; subarticular tubercles low, flat; under surface of foot granular, but lacking trace of supernumerary tubercles; outer metatarsal tubercle relatively well developed, less than half inner, which is somewhat more than half length of first toe; no distinct tarsal fold, but the inner edge of tarsus with somewhat thickened or swollen skin, forming a rounded surface, and usually light colored (in some specimens it suggests a greatly thickened glandular fold); outer edge of tarsus with an indistinct row of granules that may be somewhat connected; when legs are placed at right angles to body the heels overlap a little; upper surface of thigh and tibia with numerous tubercular granules, often forming indistinct rows; posterior face of femur almost smooth.

*Color.* Above dark blackish-brown, with some indistinct lighter areas; limbs, light cream-brown, strongly banded with dark, or black-brown; sides with numerous cream spots; side of head and lip with lighter areas, the blackish color forming bands on lip; chin heavily pigmented; breast with some dark flecks and blackish reticulation; posterior surface of femur purplish-brown with cream spots, lines, or reticulation; under surface of tibia with black spots, continuations of the dorsal dark bands; foot, heel, and to some extent hand, purplish; inguinal gland yellow; scattered pigment in buccal cavity, especially two lines under tongue and on floor of mouth.

*Measurements in mm.: Eleutherodactylus matudai* sp. nov.

| Number | 110626 | 110624 | EHT-HMS 24353 | 110625 | 110628 | EHT-HMS 24354 |
|---|---|---|---|---|---|---|
| Sex | ♀ | ♀ | ♀ | ♀ | ♂ | ♂ |
| Snout to vent | 40.0 | 38.0 | 37.1 | 37.0 | 28.0 | 27.0 |
| Width of head | 17.3 | 16.0 | 16.1 | 17.0 | 13.5 | 12.7 |
| Length of head | 14.5 | 14.5 | 14.1 | 15.4 | 12.0 | 11.1 |
| Diameter of tympanum | 3.0 | 3.0 | 2.9 | 2.9 | 3.4 | 3.1 |
| Diameter of eye | 5.5 | 5.2 | 4.8 | 4.9 | 3.9 | 3.5 |
| Eye to nostril | 3.9 | 3.5 | 3.6 | 3.5 | 3.0 | 2.6 |
| Eye to tip of snout | 7.0 | 6.9 | 7.0 | 7.0 | 5.4 | 5.1 |
| Length of snout | 6.1 | 5.9 | 6.2 | 6.1 | 5.0 | 4.7 |
| Arm | 23.0 | 23.0 | 22.2 | 24.1 | 18.0 | 16.4 |
| Leg | 76.0 | 73.0 | 75.2 | 72.5 | 53.0 | 53.0 |
| Tibia | 25.5 | 24.8 | 24.0 | 24.2 | 19.0 | 17.4 |
| Foot | 34.0 | 33.0 | 34.1 | 34.5 | 24.2 | 23.0 |

*Variation.* The usual sexual dimorphism in size of body and of tympanum is strongly evident. Certain of the specimens have the canthal ridges a little more pronounced and a tiny ridge arising posterior to the nostril, converging in the frontal region, but not meeting; the supratympanic fold begins below and anterior to the corner of the eye; on the back of head the area enclosed in the glandular folds is more elevated than areas lateral to them, as if the edges of the frontoparietals were somewhat elevated (visible in figure of male). In one specimen the vomerine tooth patch is wanting on the left side (110623); the tongue is usually emarginate or notched behind and usually is more elongate than that in type.

Pigmentation inside the mouth varies. There are usually two lines visible under tongue running back; occasionally there are pigment flecks on the tongue and on roof of mouth.

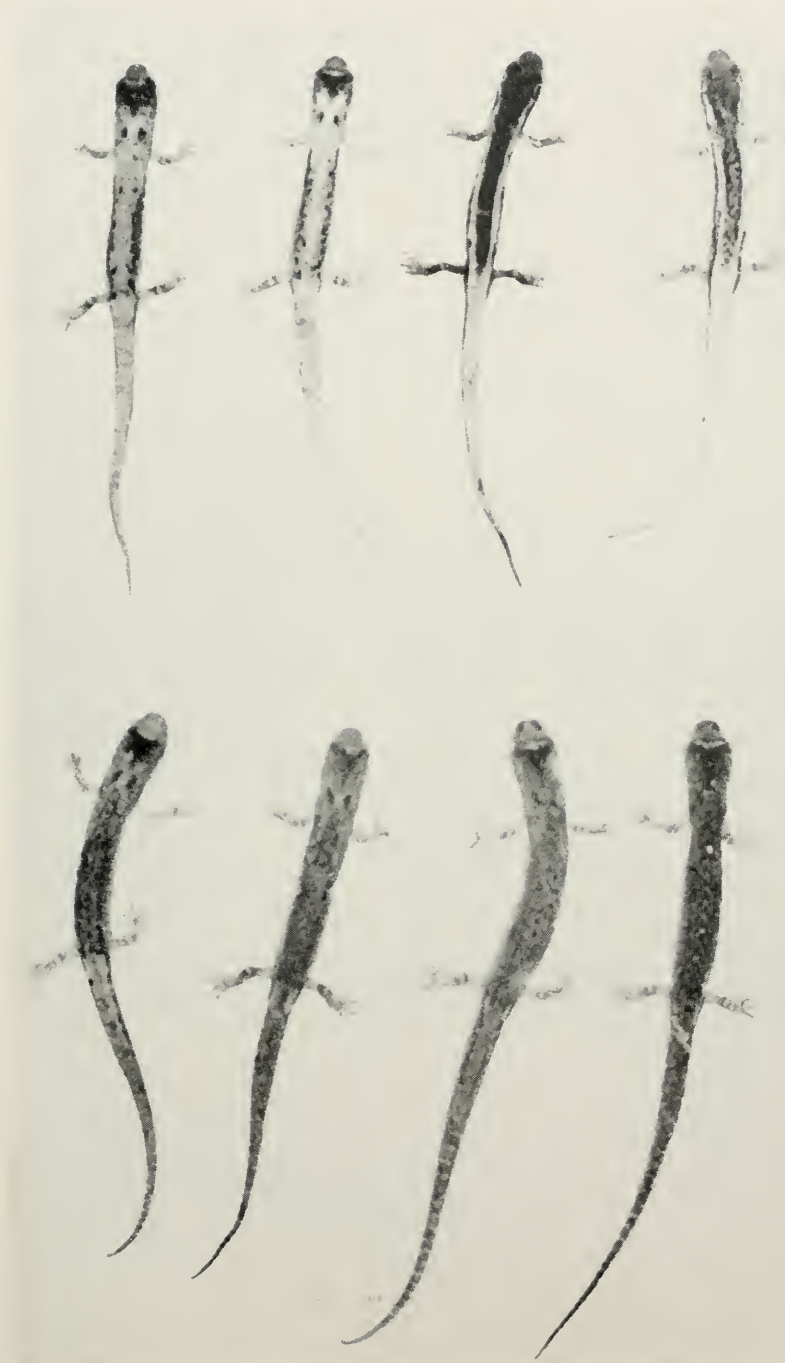
The species is named for Mr. Matuda, host to Dr. and Mrs. Hobart M. Smith during their sojourn at Hda. La Esperanza, Chiapas.

It differs from other Mexican species, and appears to have its relationship with *E. biporcatus* (judging by the description), which has a similar elevation of the frontoparietal region. *E. matudae* differs in lacking the interorbital concavity, the vomerine teeth do not form an arched series, and the first finger is shorter or at most equal to second.

## PLATE VII

PLATE VII. *Bolitoglossa xolocalcae* sp. nov. Paratypes. Mount Ovando, Chiapas, Mexico. Upper row, left to right, EHT-HMS, 27264, 27265, 27266, 27267; lower row, 27268, 27269, 27270, 27271; all about natural size.

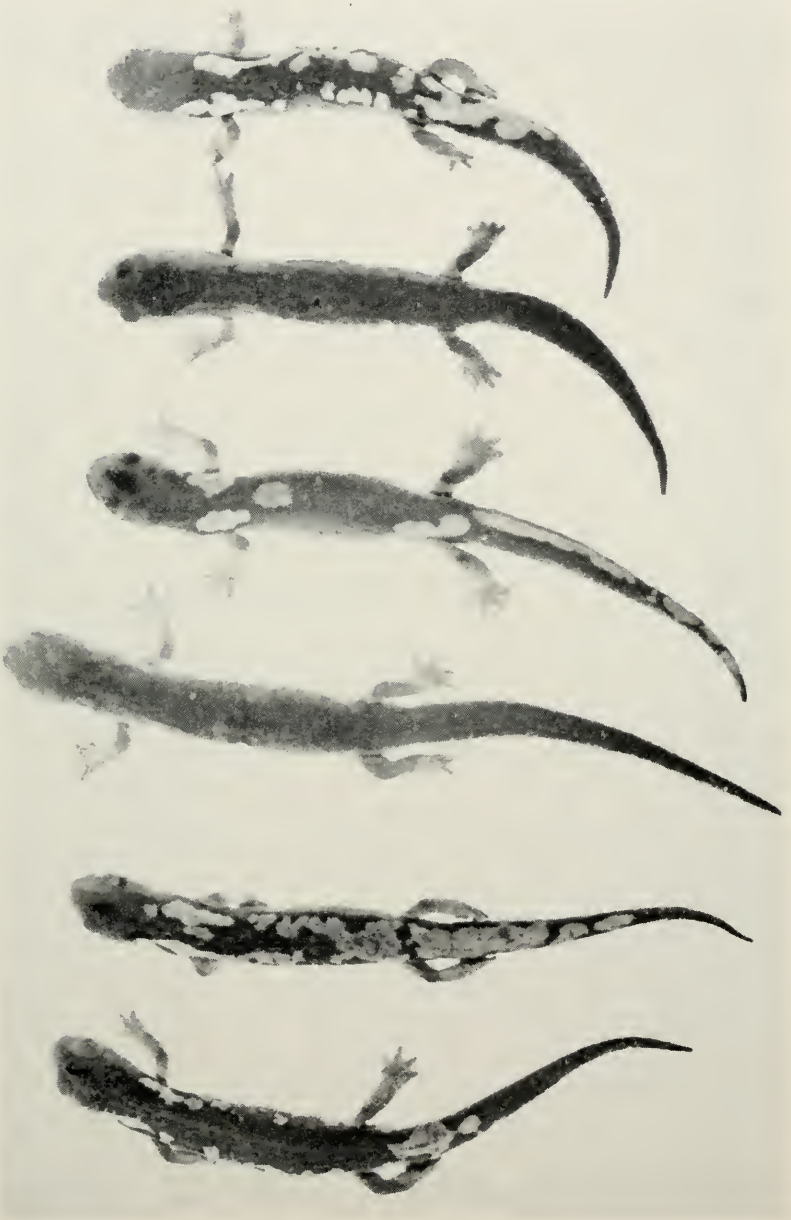
PLATE VII



## PLATE VIII

PLATE VIII. *Bolitoglossa nigroflavescens* sp. nov. Mount Ovando, Chiapas, Mexico. Left to right, USNM, Nos. 111174, 89 mm.; 111191, 90 mm.; Type 111169, 106 mm.; EHT-HMS, No. 26798, 96 mm.; USNM, Nos. 111162, 85 mm.; 111165, 80 mm.

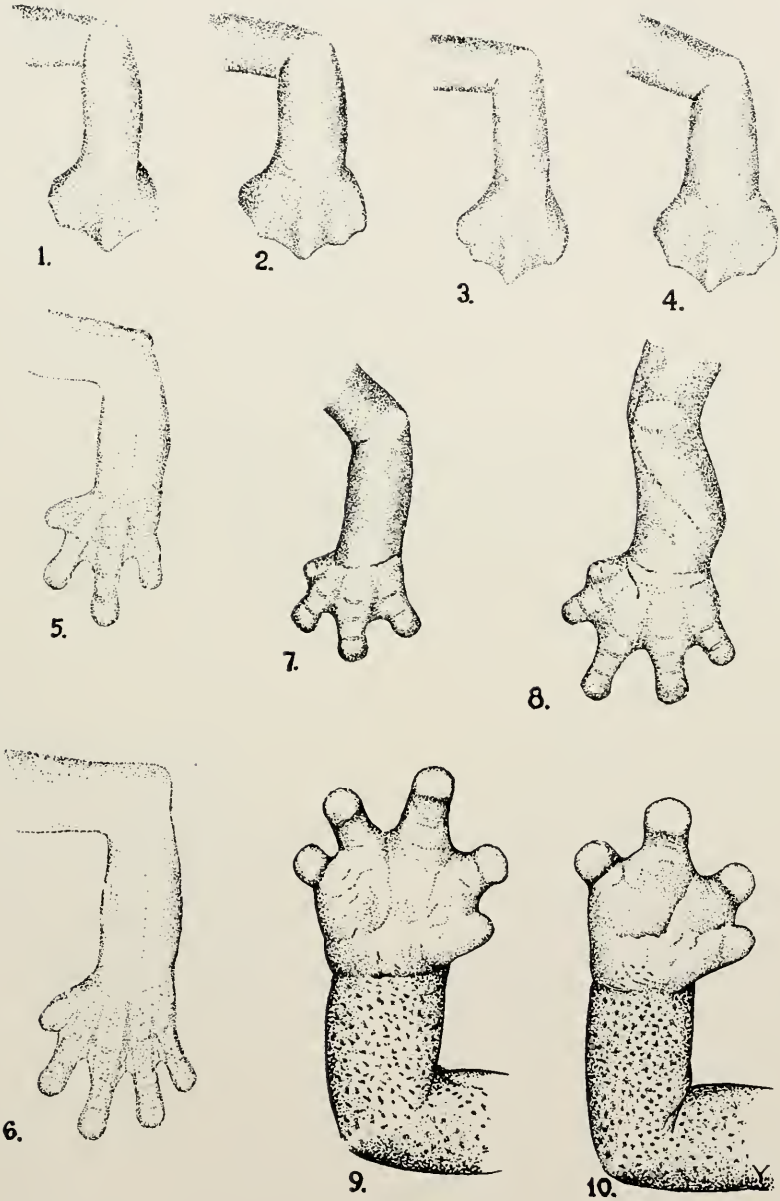
PLATE VIII



## PLATE IX

PLATE IX. Figs. 1 and 2, *Bolitoglossa occidentalis* sp. nov. Field Museum No. 20330, Paratype, El Porvenir, Guatemala; hand, and foot × 5. Figs. 3 and 4, same, Paratype, EHT-HMS, No. 24049, Finca Juarez, Chiapas, Mexico; hand and foot × 5. Figs. 5 and 6, *Bolitoglossa nigromaculata* sp. nov. USNM, No. 6340, Paratype (one of the paratypes of *Spelerpes leprosus* Cope) "Orizava, Mexico." Figs. 7 and 8, *Bolitoglossa xolocalcae* sp. nov. EHT-HMS, No. 25331, Paratype, Mount Ovando, Chiapas, Mexico; hand and foot × 5. Figs. 9 and 10, *Bolitoglossa nigroflavescens* sp. nov. EHT-HMS, No. 27263, Paratype, Mount Ovando, Chiapas, Mexico; foot and hand × 5. (Ventral view.)

PLATE IX



## PLATE X

PLATE X. *Eleutherodactylus dorsoconcolor* sp. nov. Tequeyutepec, Veracruz, Mexico. Upper, Type, No. 110619 ♀, 39.2 mm.; lower, Paratypes; left, USNM, No. 110618 ♂; right, EHT-HMS, No. 24321 ♂. Topotypes.

PLATE X

## PLATE XI

PLATE XI. *Eleutherodactylus matudae* sp. nov. Mount Ovando, Chiapas, Mexico. Upper, Paratype, EHT-HMS, No. 24353 ♀, 37.1 mm.; lower, Type, USNM, No. 110626 ♀, 40 mm.

PLATE XI

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XXVII] NOVEMBER 1, 1941 [No. 9

# The Genus *Telmatometra* Bergroth (Hemiptera-Gerridae)*

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ABSTRACT: This paper presents a key to the genera of the Halobatinae, Rhagadotarsinae and Haloveliinae of the world and a key to the species of the genus *Telmatometra* Bergroth. Descriptions have been prepared for *T. whitei* Bergroth, *T. ujhelyii* Esaki, *T. Rozeboomi* Drake and Harris, and for the following new species: *T. acuta*, from Peru, South America, *T. fusca*, from Brazil, South America, *T. indentata* from Bolivia, South America, *T. parva*, from Brazil, South America, and *T. retusa*, from Bolivia, South America.

THE family Gerridae, to which the genus *Telmatometra* Bergroth belongs, is divided into five subfamilies, which may be separated as follows:

A. Inner margins of eyes sinuate or concave behind the middle. Body and abdomen comparatively long and narrow.
  B. First segment of the antennae shorter than the other three conjoined; middle and hind femora not longer than the whole length of the body.....*Gerrinae.*
  BB. First segment of the antennae not shorter than the other three conjoined. Middle and hind femora, or at least one of them, longer than the whole length of body .....*Ptilomerinae.*
AA. Inner margins of eyes convexly rounded. Body and abdomen comparatively short and broad.
  B. Genae produced to a spine-like point.....*Rhagadotarsinae.*
  BB. Genae not produced to a spine-like point.
    C. Eyes broader than long; body not over 3 mm. long.....*Haloveliinae.*
    CC. Eyes as long as broad, or longer; body usually over 3 mm. long. *Halobatinae.*

Since keys to the genera of Gerrinae and Ptilomerinae will be found elsewhere, it is necessary to give only the keys to the genera

* Submitted to the Department of Entomology and the faculty of the Graduate School of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Arts.

† *Acknowledgment.* The writer wishes to express his sincere appreciation to Dr. H. B. Hungerford, under whose direction this study was undertaken, for the benefit of his experience in taxonomy and his knowledge of the literature. Thanks are also due to Dr. R. H. Beamer for his helpful suggestions.

of the last three subfamilies. Rhagadotarsinae embraces only the genus *Rhagadotarsus* Breddin. The genera of the other subfamilies may be separated as follows:

### Subfamily *Haloveliinae*

1. First segment of antenna longer than third ..... 2
1. First segment of antenna shorter than third ..... 3
2. (1) Middle femur with a row of very long stout setae on outer margin. *Xenobates* Esaki.
2. Middle femur without conspicuous setae ..... *Halovelia* Bergroth.
3. (1) Second segment of antenna longer than first ..... *Strongyvelia* Esaki.
3. Second segment of antennae shorter than first ..... *Entomovelia* Esaki.

### Subfamily *Halobatinae*

1. Tibia and first tarsal segment of middle leg with a fringe of long hairs. Marine ..... *Halobates* Eschscholtz.
1. Tibia and first tarsal segment of middle leg without a fringe of long hair .... 2
2. (1) Second antennal segment shortest, or second and third subequal; second, third, and fourth segments not subequal; first segment longest ..... 3
2. Second antennal segment not shortest, or second, third, and fourth segments subequal; first segment not always longest ..... 14
3. (2) First tarsal segment of fore leg longer than second tarsal segment ..... 4
3. First tarsal segment of fore leg not longer than second tarsal segment ..... 5
4. (3) First antennal segment at least three times length of second. New world genus. *Charmatometra* Kirkaldy.
4. First antennal segment at most twice the length of second. Old world genus. *Chimarrhometra* Distant.
5. (3) First tarsal segment less than one-half length of second tarsal segment in fore leg ..... 7
5. First tarsal segment at least one-half length of second segment in fore leg .. 6
6. (5) Thorax and abdomen with heavy, black, longitudinal stripes. *Eobates* Drake and Harris.
6. Thorax and abdomen with no heavy markings, may have faint bars or stripes. *Brachymetra* Mayr.
7. (5) Long hairs on third antennal segment and on posterior margin of eyes; abdomen pointed; males often with deformed, incrassate, or curved hind femur and antenna ..... *Rheumatobates* Bergroth.
7. Long hairs on third antennal segment absent; males without deformed or incrassate hind femur ..... 8
8. (7) Rostrum reaching middle of mesosternum. Old world genus. *Cryptobates* Esaki.
8. Rostrum not reaching beyond anterior two-thirds of mesosternum ..... 9
9. (8) Hind femur longer than middle tibia. Old world genera ..... 10
9. Hind femur shorter than middle tibia. New world genera ..... 11
10. (9) Fourth antennal segment longest ..... *Imemboa* Esaki.
10. Fourth antennal segment not longest ..... *Metrocoris* Mayr.
11. (9) Third and fourth antennal segments longest ..... *Telmatometra* Bergroth.
11. Third and fourth antennal segments not the two longest ..... 12
12. (11) First five abdominal segments considerably narrowed toward apex of abdomen. From side view, eyes not extending beyond anterior half of prothorax at that point ..... *Trepobates* Uhler.
12. First five abdominal segments not considerably narrowed toward apex of abdomen. From side view, eyes extending beyond anterior half of prothorax at that point ..... 13
13. (12) Middle tibia as long as body or longer ..... *Halobatopsis* Bergroth.
13. Middle tibia shorter than body length (*T. rozeboomi*) .. *Telmatometra* Bergroth.
14. (6) Intermediate tibia not the longest leg segment ..... 15
14. Intermediate tibia longest leg segment ..... 21
15. (14) Anterior leg with three tarsal segments ..... *Hermatobates* Carpenter.

15. Anterior leg with two tarsal segments..... 16
16. (15) Interocular space at narrowest point narrower than eye width..*Platygerris* White.
16. Interocular space at narrowest point wider than eye width..... 17
17. (16) First antennal segment as long as other three segments together.
*Esakia* Lundblad.
17. First antennal segment shorter than other three segments united..... 18
18. (17) Interocular space at widest point twice eye width.....*Asclepios* Distant.
18. Interocular space at widest point not twice eye width..... 19
19. (18) Body width more than two-thirds body length. Mesothoracic acetabula nearly vertical in position with metathoracic acetabula. Mesothoracic acetabula scarcely visible from dorsal view. Male genital segments large.....*Metrocoris* Mayr.
19. Body width two-thirds or less than body length. Mesothoracic acetabula plainly seen infero-laterad of metathoracic acetabula from dorsal view. Male genital segments small ..... 20
20. (19) Eyes extending postero-laterally, reaching mesonotum; dorsal surface of body conspicuously convex.....*Ventidius* Distant.
20. Eyes extending postero-laterally, not reaching mesonotum, dorsal surface of body nearly flat.....*Eurymetra* Esaki.
21. (14) Intermediate femur longer than posterior femur; interocular space at narrowest point twice width of eye.....*Rheumatometra* Kirkaldy.
21. Intermediate femur shorter than posterior femur; interocular space at narrowest point not twice width of eye..... 22
22. (21) First antennal segment as long as other 3 united.....*Metrobates* Uhler.
22. First antennal segment not as long as other three united..... 23
23. (22) Tibia of anterior leg much flattened, blade-shaped, widest at distal apex; pronotum with posterior margin sinuate in apterous form.....*Stenobates* Esaki.
23. Tibia of anterior leg not much flattened nor blade-shaped; pronotum with posterior margin rounded, not sinuate in apterous form..... 24
24. (23) Eyes extending postero-laterad, nearly touching metathorax.
*Metrobatopsis* Esaki.
24. Eyes slightly extending postero-laterad, not extending beyond anterior half of prothorax at that point.....*Naboandelus* Distant.

## *Telmatometra* Bergr.

*Telmatometra* Bergroth, Ohio Nat. VIII, p. 374, 1908. T. Esaki, Ann. Mus. Nat. Hung., Vol. XXIII, p. 133, 1926.

### APTEROUS FORM

Eye width subequal or slightly narrower than interocular space. Eyes, from lateral view, extending to or posterior to anterior half of prothorax. Antennal length over half of body, first segment arched, third and fourth segments often much curved; second segment always shortest, third usually longest, fourth sometimes longest. Rostrum extending posteriorly to anterior one-third of mesosternum. Pronotum shorter and much narrower than head, anterior margin straight, posterior margin variable, lateral margins much rounded. Mesonotum distinctly defined from metanotum, moderately convex, much widened posteriorly, anterior margin usually straight, lateral margins slightly sinuate exteriorly, posterior margin nearly straight, but slightly depressed at middle, lateral portions somewhat protruding posteriorly. Metanotum with anterior margin nearly straight, but slightly projecting anteriorly at middle; posterior margin much arcuate anteriorly. First and second abdominal segments divided

by a rather indistinct sinuate suture curved somewhat anteriorly. Posterior margin of second abdominal segment straight. Five more abdominal segments (last one longest) and two genital segments visible dorsally. Last ventral abdominal segments at least as long as preceding three. Anterior femur as long or longer than mesonotum; tibia at least two-thirds length of femur; tarsus less than half length of tibia, first segment about one-quarter length of second. Intermediate femur about two-thirds length of tibia; tibia at least as long as medial length from apex of abdomen to anterior margin of pronotum, occasionally as long as body; tarsus about as long as femur, first segment longer than second. Hind femur shorter than intermediate tibia; tibia about two-thirds length of femur; tarsus about half length of tibia, first segment subequal to second or a little longer.

Male differs from female in proportions and size, male being smaller. Male pronotum as long or longer than that of female, longer in proportion to mesonotum than female. Length from apex of head to mesometanotal line, medially, noticeably longer in male than length from mesometanotal line to apex of abdomen; subequal in female. Male body length in proportion to width longer than in female.

*T. rozeboomi* differs from this generic description by having first and fourth antennal segments longer than the third, and female body length in proportion to width longer than the same proportions in male.

### MACROPTEROUS FORM

Pronotum extending backwards over mesonotum, occasionally over anterior portion of metanotum, widening from head to humeral angles and then gradually tapering to rather narrowly rounded apex; anterior margin straight. Wings blackish, usually broken, exposing all of abdominal segments except first two.

## Key to *Telmatometra* Bergroth

### Apterous Forms

| | | |
|---|---|---|
| 1. | | First antennal segment subequal to third..... ....*T. rozeboomi* D. and H. |
| 1. | | First antennal segment not subequal to third..... 2 |
| 2. | (1) | Pairs of dark black longitudinal bands on mesonotum not reaching posterior margin.....*T. whitei* Bergroth. |
| 2. | | All dark longitudinal bands on mesonotum reaching posterior margin..... 3 |
| 3. | (2) | Anterior margin of mesonotum black..... 4 |
| 3. | | Anterior margin of mesonotum not black nor dark..... 5 |
| 4. | (3) | Posterior femur slightly over twice length of tibia.....*T. acuta* sp. n. |
| 4. | | Posterior femur less than twice length of tibia.....*T. ujhelyii* Esaki. |
| 5. | (3) | Mesothorax with two black longitudinal stripes on sides with prominent silvery sheen or white stripe between them.....*T. retusa* sp. n. |

5. Mesothorax with two dark longitudinal stripes on sides with no prominent silvery sheen or white stripe between them..... 6
6. (5) First genital segment of male ventrally emarginated, reaching posterior margin of last abdominal segment, acutely V-shaped. Markings on head very dark and distinct.....*T. indentata* sp. n.
6. First genital segment of male ventrally emarginated, not nearly reaching posterior margin of last abdominal segment, broadly V-shaped. Markings on head light and indistinct..... 7
7. (6) Median dark line on posterior half of mesonotum. Anterior femur black ventrally. Male with median longitudinal groove on first genital segment, ventrally. *T. parva* sp. n.
7. No median dark line on posterior half of mesonotum. Anterior femur dark ventrally. Male with median saucer-shaped depression on first genital segment, ventrally.....*T. fusca* sp. n.

## *Telmatometra whitei* Bergroth

*Telmatometra whitei*, Bergroth, Ohio Nat. VIII, p. 374, 1908. Drake and Harris, Rev. de Entomologia vol. 7, fasc. 4, p. 360, 1937.

### APTEROUS FORM

*Size.* Males 4.6-4.8 mm. long, 2.0-2.1 mm. wide; female 5.0-5.5 mm. long, 2.2-2.7 mm. wide.

*Color.* Body dark yellow, with black and white markings. Antenna dark, apical third of rostrum dark. Head with variable dark markings near margins of eyes. Pronotum with margin between eyes dark and from each end projects a bar to posterior one-third of segment. Mesothorax with three pairs of dark longitudinal bands extending posteriorly, most dorsal pair diverging slightly posteriorly, but not reaching posterior margin of mesonotum. The two more ventral pairs of dark longitudinal bands on sides reach posterior margin and enclose a band of silvery sheen. Usually a short dark median mark on posterior half of mesonotum. Coloring on metanotum and dorsal abdominal segments variable, almost completely black or merely dark margins to segments. Venter lighter with a discontinuous dark longitudinal stripe on side of mesosternum. Legs dark except femora, which have several dark longitudinal stripes.

*Structural characteristics.* Antennal formula variable: 1st:2d:3d:4th::22-25:14:28-32:23-26 in males, 21-23:12:28-30:20-21 in females. Interocular space much wider than eye width. Anterior femur slightly shorter than medial length of pronotum and mesonotum; tibia about seven-ninths length of femur, distal third clothed with moderately long hairs; tarsus about two-fifths length of tibia, first segment one-fourth length of second. Intermediate femur about five-eighths length of tibia; tibia subequal to length of body; tarsus about four-fifths length of femur, first segment one and a half times longer than second. Hind femur about one and a half times longer than tibia; tarsus about one-half length of tibia; first

segment subequal to second. Pronotum:mesonotum::3.3:9.3 in male; 3.0:10.5 in female. Last ventral abdominal segment equal to preceding three segments. Clasper with a rather straight shaft and a hook curving abruptly up, short and pointed. First genital segment not flattened or depressed ventrally.

MACROPTEROUS FORM

*Size.* Male, 5.0 mm. long, 2.0 mm. wide; female 5.0-5.6 mm. long, 2.1-2.4 mm. wide.

*Color.* Pronotum with anterior and lateral margins dark. A pair of bars extending posteriorly from inner corner of eye, forming a pi ($\pi$) shaped mark. Median dark stripe the shape of exclamation mark, reaching neither anterior nor posterior margin. Wings black.

*Structural characteristics.* Pronotum extending back to meso-metanotal line. Wings twice length of pronotum.

*Notes.* *T. whitei* similar to *T. ujhelyii,* differs by extra pair of dark longitudinal black bands on mesonotum, clasper with stout, rather straight shaft, hook curved up abruptly at right angle, not so abruptly pointed as *T. ujhelyii.* Distribution. Costa Rica through Mexico.

*Telmatometra ujhelyii* Esaki

*Telmatometra ujhelyii* T. Esaki, Ann. Mus. Nat. Hung. XXIII, p. 132, 1926. Drake and Harris, Rev. de Entomologia, vol. 7, fasc. 4, p. 360, 1937.

APTEROUS FORM

*Size.* Male, 4.0 mm. long, 1.7 mm. wide; female, 4.5-4.7 mm. long, 2.0-2.2 mm. wide.

*Color.* Body dark yellow, with black and white markings. Antenna dark brown or black. Head with black markings following margins of eyes, variable. Pronotum margined in black except a narrow spot back of eyes; usually a dark mark on median third. Mesothorax with two parallel black longitudinal stripes on sides reaching from anterior to posterior margin and surrounding a stripe of silvery sheen. Median dark mark dorsally reaching from anterior to posterior margin. One dark dash-like mark back of anterior leg and two in front of intermediate legs. Metathorax and abdominal segments variable dorsally, from complete blackness to merely black margined segments; ventrally, light yellow. Basal one-fourth of anterior femur yellow, and dorsal side of anterior, intermediate and posterior femora with longitudinal yellow stripes, otherwise black.

*Structural characteristics.* Antennal formula: 1st:2d:3d:4th::-20:11:24:24 in female. Interocular space much wider than eye

width. Anterior femur subequal to combined medial length of pronotum and mesonotum; tibia about seven-tenths length of femur and clothed beneath with moderately long hair; tarsus about half length of tibia, first segment one quarter length of second. Intermediate femur three-fifths length of tibia; tibia slightly shorter than body length; tarsus two-thirds length of femur, first tarsal segment longer than second. Posterior tibia three-fifths length of femur; tarsus less than half length of tibia; first segment subequal to second. Pronotum:mesonotum::2.0:7.1 in female. Last ventral segment subequal to preceding four.

MACROPTEROUS FORM

*Size.* (Without wings) Males, 4.8-5.1 mm. long, 2.0-2.1 mm. wide; female, 5.9-6.1 mm. long, 2.3-2.4 mm. wide.

*Color.* Pronotum dark yellow, margined in black except for a narrow band back of eyes. Broad black exclamation-shaped median mark, touching neither anterior nor posterior margins. Anterior margin with a pair of very short black marks projecting posteriorly.

*Structural characteristics.* Pronotum extending slightly posterior to mesonotum in female, to mesonotum in males. First genital segment in male flattened slightly on ventral side, but not depressed. Clasper with comparatively long, straight shaft with abrupt hook short and sharp-pointed, and turned at right angle to shaft, very thick at curve.

Types in Hungarian National Museum, Budapest, Hungary.

*Notes.* *T. ujhelyii* similar to *T. whitei*, differs by lack of extra mesonatal black bars, by yellow mark back of eye which breaks up black anterior margin of pronotum, by claspers with hook coming to a point more abruptly, very thick at curve. Distribution, Colombia through British Hondurus.

*Telmatometra rozeboomi* Drake and Harris

*Telmatometra rozeboomi* Drake and Harris, Rev. de Entomologia, vol. 7, fasc. 4, p. 358, 1937.

APTEROUS MALE

"Head pale yellowish-brown, with a median blackish stripe, blackish on sides in front and brownish-black along inner margin of eyes. Antennae long, slender, dark brown, the basal two-thirds of segment I testaceous; segment I stout, curved, slightly enlarged distally; proportions, I:II:III:IV::37:25:36:38. Rostrum yellowish-brown, darker above, extending to middle of mesosternum. Anterior legs with femur and tibia considerably curved, brown, pale

beneath, the tibia flattened; tarsi brown, segment I very short. Intermediate legs very long, yellowish tibia without long hairs and a little more than one and one-half times as long as femur; tarsi long, the basal segment longer than the last. Hind legs much shorter, the tibiae and tarsi brown. Pronotum yellowish-brown, moderately impressed on the disk, the median blackish stripe widened behind, not reaching basal margin, each side with a broad, somewhat C-shaped brownish-black mark. Mesonotum roundly excavated behind, the very broad, black stripe on each side divided on the anterior two-thirds by a longitudinal yellowish stripe, the median black stripe considerably broadened in front and extending to apex. Abdomen with hind margin of last five segments and a broad stripe on each connexivum yellowish-brown. First genital segment above yellowish-brown, darkened at the hind margin; distinctly emarginate at apex; beneath testaceous, pilose, somewhat flattened. Claspers brown, slightly curved."

Length, 3.15 mm.; width, 1.30 mm.

"Apterous female: Much larger than male, color and markings very similar, but with the median black stripe of mesonotum more than twice as broad. Abdominal segments above more broadly margined with yellowish-brown. Body more slender than *ujhelyii*."

Length, 3.7 mm.; width, 1.5 mm.

"Holotype, apterous male, and allotype, apterous female, Canal Zone, Panama, 1935, Dr. Lloyd J. Rozeboom. In both male and female the sides of mesothorax are plump and not longitudinally impressed as in *whitei* and *ujhelyii*. Although congeneric with these species, *rozeboomi* in many characters approaches the genus *Trepobates* Uhler."

*Notes.* *T. rozeboomi* differs from other species of this genus by having first and fourth antennal segments longer than the third. Female body length in proportion to width longer than the same proportions in male.

### *Telmatometra acuta* sp. nov.

#### APTEROUS FORM

*Size.* 3.6-3.8 mm. long, 1.3-1.4 mm. wide in males; 4.1-4.6 mm. long, 1.8-2.1 mm. wide in females.

*Color.* Body yellowish-tan, with black and white markings. Antenna blackish, pronotum, mesonotum, and metanotum with black median marks of varying length and width. Margins of head, prothorax, mesothorax, metathorax and abdominal segments darkly

margined dorsally, except part of posterior margin of pronotum. Mesothorax with two longitudinal black bands on side meeting at anterior and posterior ends around a white longitudinal band, all three bands nearly equal in width, black bands usually wider. First abdominal segment mostly black. Rostrum with fourth and distal half of the third segment black. Legs brownish except ventral side of legs, often with dorsal longitudinal yellow stripes on intermediate and posterior femora. Irregular dark spot on lateral side of mesothorax sometimes extending anterior to mesothoracic legs.

*Structural characteristics.* Antennal formula: 1st:2d:3d:4th::-17:11:26:26 in male; 18:12:29:28 in female, slightly variable. Interocular space slightly wider than eye width. Anterior femur longer than mesonotum medially, thicker than posterior femur, thinner than intermediate femur; tibia four-fifths length of femur, distal two-thirds clothed with moderately long hair; tarsus less than half length of tibia, first segment about one-fourth length of second. Intermediate femur about three-fourths as long as tibia; tibia as long as body, excepting genital segments; tarsus about five-sixths length of femur, first segment slightly longer than second. Posterior femur shorter than intermediate tibia, a little over twice length of posterior tibia; tarsus one-half length of tibia, first and second segments subequal. Pronotum: mesonotum::2.8:7.7 in male, 2.4:9.0 in female. Last ventral abdominal segment subequal in length to preceding four medially. Clasper sickle-shaped and sharp pointed. First genital segment of male with a broad saucer-shaped depression, ventrally.

Holotype, apterous male; allotype; six paratypes, Department Huanuca, Vic. of Afilador Jungle, 800 m. Peru, S. A., June 3-7, 1937, No. 3765, F. Woytkowski; four paratypes, Department Huanuca, Loc. Shapjilla Jungle, 630 m, Peru, S. A., July 5 to Aug. 10, 1938, No. 3831, F. Woytkowski. All types located in Francis Huntington Snow Entomological Museum, University of Kansas, Lawrence, Kansas.

*Notes. T. acuta* is closest to *T. ujhelyii*, differs by posterior femur being slightly over twice length of tibia, medial dark mark on mesothorax if complete from anterior to posterior margins, very slender, light. Clasper of male sickle-shaped; point much longer than in *T. ujhelyii*.

*Telmatometra fusca* sp. nov.

APTEROUS FORM

*Size.* Male, 3.3-3.7 mm. long, 1.1-1.4 mm. wide; female, 3.7-4.2 mm. long, 1.7-1.9 mm. wide.

*Color.* Yellowish-brown, antenna with apical ends of segments darker, mesothorax with two dark longitudinal stripes on each side, lower one usually not reaching anterior or posterior margin of mesothorax. Dark, transverse stripe between metanotum and first abdominal segment. Anterior tarsus, intermediate tibia and tarsus, also posterior tarsus, dark, all other segments darkened apically. Rostrum with apical end darkened.

*Structural characteristics.* Antennal formula variable: 1st:2d:-3d:4th::16:10-11:23-29:25-28 in male; 16:9-10:23-26:22-25 in female. Third or fourth segment may be longest in both sexes. Interocular space slightly wider than eye width. Anterior femur longer than mesonotum medially, thicker than posterior femur, thinner than intermediate femur. Tibia four-fifths length of femur, distal one-third clothed with moderately long hairs beneath, tarsus a little over one-third length of tibia, first segment about one-fourth length of second. Intermediate femur about three-fifths length of tibia, tibia at least as long as medial length from tip of abdomen to mesopronotal division, tarsus nearly equal to length of femur, first segment slightly longer than second. Posterior femur about twice length of tibia, tarsus about two-fifths length of tibia, first segment about subequal to second. Pronotum:mesonotum::2.7:6.8 in males; 2.7:8.0 in females. Last ventral abdominal segment subequal to preceding four, ventrally. Clasper curving gradually upwards, thickened at base. Male first genital segment with a broad saucer-shaped depression ventrally, margin emarginate, broadly u-shaped.

MACROPTEROUS FORM

*Size.* Female, 4.0 mm. long, 1.7 mm. wide.

*Color.* Same as apterous. Pronotum darkly margined except anterior margin. Median dark line like exclamation mark which reaches neither anterior nor posterior margin of pronotum.

*Structural characteristics.* Intermediate tibia as long as medial distance from anterior margin of pronotum to apex of abdomen. Pronotum extending back to anterior margin of metanotum. Wings black and broken off above posterior margin of metanotum.

Holotype, apterous male, allotype, and fifty-six paratypes Vic. Joao Passoa (Sao Philipe) River Jurua, Brazil, S. A., July 10 to Sept. 20, 1936, Nos. 375, 376; 379, A. M. Olalla. Forty-six paratypes,

Vic. Santo Antonio, River Eiru, Brazil, S. A., Sept. 25 to Oct. 1, 1936, Nos. 3713, 3714, A. M. Olalla. All types in Francis Huntington Show Entomological Museum, University of Kansas, Lawrence, Kan.

*Notes.* *T. fusca* is similar to *T. parva* and *T. indentata,* differs by having no median mesonotal mark in male or female; Clasper is curved and abruptly pointed, being intermediate between *T. parva* and *T. indentata.*

*Telmatometra indentata* sp. nov.

APTEROUS FORM

*Size.* Males, 3.3-3.5 mm. long, 1.3-1.5 mm. wide; females, 3.6-4.1 mm. long, 1.6-1.7 mm. wide.

*Color.* Body reddish-amber, lighter on venter. Antennae and legs dark brown except for proximal half of anterior femur and trochanter and longtitudinal stripes on intermediate and posterior femur, which are light tan. Apical half of rostrum dark. Head with dark spots near margins of eyes. Mesothorax with two parallel longitudinal dark stripes on side, meeting anteriorly, usually not posteriorly; female with dark median mark on posterior half, male without it usually. Metanotum with median dark mark running to posterior margin, meeting dark, transverse mark.

*Structural characteristics.* Antennal formula: 1st:2d:3d:4th::17:10:25:21 in male; 15:8:21:17 in female. Interocular space slightly wider than eye width. Anterior femur longer than mesonotum, wider than posterior femur, thinner than intermediate femur. Tibia five-sixths length of femur and twice tarsus, clothed the full length with moderately long hairs. First tarsal segment about one-fourth length of second. Intermediate tibia as long as body in male, slightly shorter in female. Femur seven-tenths length of tibia and slightly longer than tarsus; first tarsal segment nearly twice length of second. Posterior femur about twice length of tibia; tibia about twice length of tarsus; first tarsal segment about subequal to second. Pronotum: mesonotum::2.5:6.5 in males; 2.3:7 in females. Last ventral abdominal segment long as preceding four, with median V-shaped groove in male. Claspers tapering gradually to point from a stout base, curved somewhat. Last genital segment of male ventrally emarginated, acutely V-shaped, reaching posterior margin of last ventral abdominal segment, appearing as a median, narrow, V-shaped groove.

Holotype, apterous male, allotype, and eighty-four paratypes, R. Beni Cacheula, Esperanza, Bolivia, S. A., Sept. '37, A. M. Olalla.

All types in Francis Huntington Snow Entomological Museum, University of Kansas, Lawrence, Kan.

*Note.* *T. indentata* is similar to *T. fusca* and *T. parva,* differs by having female with median stripe on posterior margin of mesonotum, male without median stripe; male with first genital segment ventrally emarginated, reaching posterior margin of last ventral abdominal segment, clasper similar, but more pointed.

*Telmatometra parva* sp. nov.

*Size.* Males, 3.2-3.4 mm. long, 1.1-1.2 mm. wide; females, 3.7-3.8 mm. long, 1.6 mm. wide.

APTEROUS FORM

*Color.* Amber brown, venter lighter. Antenna and appendages dark brown except proximal quarter of femur and trochanter, which is light brown. Basal two-thirds of rostrum dark brown. Mesothorax with two dark red longitudinal stripes on side and median mark on posterior third. Metathorax usually with median dark line and posterior margin dark. Posterior margin of abdominal segments darkly margined.

*Structural characteristics.* Antennal formula: 1st:2d:3d:4th::-15:9:25:23 in male; 14:8:19:? in female. Interocular space wider than eye width. Anterior femur subequal to mesonotum medially, thicker than posterior femur and thinner than intermediate femur. Tibia about five-sixths length of femur, two and a half times as long as tarsus, distal half clothed with moderately long hairs ventrally; first tarsal segment about one-fourth length of second. Intermediate femur seven-tenths length of tibia; tibia longer than median length from anterior pronotal margin to apex of abdomen; tarsus slightly shorter than femur, first segment longer than second. Posterior femur over twice length of tibia; tarsus about one-half length of tibia, first segment subequal to second. Pronotum:mesonotum::-2.3:6.7 in males; 2.0:7.2 in females. Last ventral abdominal segment subequal in length to preceding four in female, slightly shorter in male. Clasper curving rather abruptly with stout base and sharp point. First genital segment of male with parallel sided groove medially.

Holotype, apterous male, allotype, and three paratypes, Vic. Santo Antonio, River Eiru, Brazil, S. A., Sept. 25 to Oct. 17, 1936, No. 3712, A. M. Olalla. All types in Francis Huntington Snow Entomological Museum, University of Kansas, Lawrence, Kansas.

*Notes.* *T. parva* is similar to *T. fusca* and *T. indentata,* differs by always having median mesonotal mark on males and females.

Claspers curved more abruptly and more sharply pointed. First genital segment of male with median V-shaped groove, posterior margin emarginate, U-shaped, not reaching posterior margin of last ventral abdominal segment.

*Telmatometra retusa* sp. nov.

APTEROUS FORM

*Size.* Males, 3.5-3.9 mm. long, 1.5-1.6 mm. wide; females, 3.9-4.6 mm. long, 2.0-2.1 mm. wide.

*Color.* Body, golden tan. Antennae and legs dark except for light stripes on dorsal side of femora. At least apical half of rostrum dark. Head with dark spots margining eyes. Pronotum sometimes with short, black median mark on posterior one-third. Mesothorax with two black bands on side extending from posterior to anterior margin and surrounding a narrower band of brilliant white sheen. Median black mark on posterior half of mesonotum and occasionally on anterior margin, the two never connecting to form a complete line. Metanotum with dark median line. Abdominal segments with posterior margins dark.

*Structural characteristics.* Antennal formula:1st:2d:3d:4th::17:12:28:25 in male; 17:10:21:20 in female. Interocular space wider than eye width. Anterior femur about equal to medial length of mesonotum and pronotum, wider than posterior femur and thinner than intermediate femur; tibia five-sixths length of femur, distal one-third clothed beneath with moderately long hairs; tarsus about two-fifths length of tibia, first segment about one-fourth of second. Intermediate femur about two-thirds length of tibia, tibia subequal to length of body; tarsus not as long as femur, first segment longer than second. Posterior femur about twice length of tibia; tibia over twice length tarsus, first tarsal segment a little longer than second. Pronotum:mesonotum::2.5:8.2 in males; 2.2:8.2 in females. Last ventral abdominal segment as long as preceding four. Clasper long and gently curving with a gradual tapering from base to blunt point. First genital segment of male with deep saucer-shaped depression, ventrally.

Holotype, apterous male, allotype, and eleven paratypes, road between Todos Santos and Palmer, River Chapare (Bolivia, S. A.), March, 1938, A. M. Olalla. All types in Francis Huntington Snow Entomological Museum, University of Kansas, Lawrence, Kan.

*Notes. T. retusa* closest to *T. acuta* in coloration, differs in having mesonotum darkly margined. Clasper blunter at point and gentler in curvature. *T. retusa* is closest to *T. indentata* in clasper similarity, differs by having less taper in shaft, ending in a more blunt tip.

## PLATE XII

FIG. 1. *Telmatometra fusa* sp. nov.
- a. Body
- b. Claspers

FIG. 2. *Telmatometra indentata* sp. nov.
- a. Body
- b. Clasper
- c. Ventral view of genital segments

FIG. 3. *Telmatometra retusa* sp. nov.
- a. Body
- b. Clasper

FIG. 4. *Telmatometra parva* sp. nov.
- a. Body
- b. Clasper
- c. Ventral view of genital segments

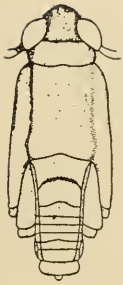
FIG. 5. *Telmatometra rozeboomi* Drake and Harris
- a. Body (From D. and H., after M. A. C.)

FIG. 6. *Telmatometra acuta* sp. nov.
- a. Body
- b. Clasper
- c. Ventral view of genital segments

FIG. 7. *Telmatometra whitei* Bergroth
- a. Body (From D. and H., after M. A. C.)
- b. Clasper

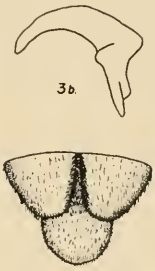
FIG. 8. *Telmatometra ujhelyii* Esaki
- a. Body (From D. and H., after M. A. C.)
- b. Clasper
- c. Ventral view of genital segments

PLATE XII



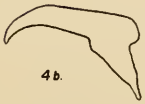
1a. T. FUSCA

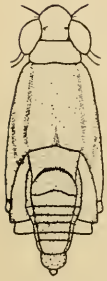
2a. T INDENTATA




2c.

3a. T. RETUSA





4a. T. PARVA

4c.

5a. T. ROZEBOOMI

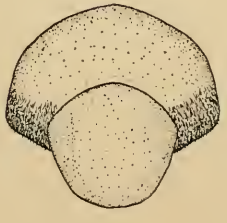
6c.

6a. T. ACUTA

7a. T WHITEI

7b.

8b.



8c

8a. T UJHELYII

THE UNIVERSITY OF KANSAS
SCIENCE BULLETIN

VOL. XXVII] NOVEMBER 1, 1941 [No. 10

# A Contribution to the Taxonomy of the Subfamily Issinae in America North of Mexico (Fulgoridae, Homoptera)

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## PART IV

ABSTRACT: This paper comprises the fourth part of a monograph dealing with the taxonomy of the subfamily Issinae (Fulgoridae, Homoptera) in America, North of Mexico. In part I* the genus *Dictyssa* was discussed. In part II† a key to twenty-one genera was given. The genus *Tylanira* Ball with only one species was accidentally left out of the key. Twelve genera were discussed in this second part, namely, *Euthiscia, Hysteropterum, Dictyonia, Dictyssonia, Dictyonissus, Neaethus, Misodema, Ulixes, Tylana, Traxus, Thionia* and *Picumna*. In part III‡ seven genera were discussed, namely, *Dictyobia, Dictydea, Osbornia, Papagona, Bruchomorpha, Dancpteryx* and *Tylanira*. In the present paper the two genera *Apheloncma* and *Fitchiella* are covered, thus completing the revision of the twenty-two known North American genera in the subfamily. The genus *Apheloncma* as revised includes twelve previously described species and two color varieties. *A. rosae* Metcalf is considered as a synonym of *A. simplex* Uhler. The following new species are described in this paper: *A. impercepta, concinna, confragosa,* and *virgata,* bringing the total list of United States species to sixteen. The genus *Fitchiella* includes eight described species. The status of this group was left practically the same as is given in Lawson's revision (1933) since little additional material was available for study and three species, namely, *A. melichari* Ball, *A. grandis* Lawson, and *A. minor* Lawson, were unfamiliar to the present writer. Additional information in regard to *Fitchiella* given in this paper concerns the description and drawings of the male genitalia. The harpagones, especially in this genus, show variation and support five of the eight species of Lawson's key.

* The University of Kansas Science Bulletin, Vol. XXIV, No. 17, 1936.

† The University of Kansas Science Bulletin, Vol. XXV, No. 20, 1938. (Mailing date, July 10, 1939.)

‡ The University of Kansas Science Bulletin, Vol. XXVI, No. 2, 1939. (Mailing date, Nov. 15, 1940.)

*Abstract of Addendum.* Additional material, involving the description of four new species, has come to the author's attention since the publication of the earlier sections of this paper. In this addendum a new species is named as *Thionia acuta* which was described under Part II as *Thionia naso* Fowl. In the genus *Neaethus* the following species are described: *unicus, consuetus* and *bicornis.* Also a correction to the key and literature of *Dictyssa* is made, namely, that *Dictyssa balli* Doering is a synonym of *Dictyssa doeringae* Ball.

## THE GENUS APHELONEMA Uhler 1876

Stal, Carolus. Novae vel minus cognitae Homopterum formae et species. Berl. Ent. Zeit. VI, p. 310. As *Peltonotus*, 1862.

Uhler, P. R. List of the Hemiptera of the Region West of the Mississippi River, Including Those Collected During the Hayden Explorations of 1873. Bul. U. S. Geol. & Geog. Surv. I, p. 356, 1876.

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Melichar, L. Bemerkungen zur Monographie der Issiden (Homoptera). Wiener Entomologische Zeitung XXVI, Jahrg., Heft X (5, October). As *Peltonotellus*, 1906.

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Van Duzee, E. P. Hemipterological Gleanings. Bul. Buf. Soc. Nat. Sci. X, p. 499, 1912.

Metcalf, Z. P. A Key to the Fulgoridae of Eastern N. America with Descriptions of New Species. Jour. Elish. Mitchell Sci. Soc. XXXVIII, p. 139, 1923.

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Bunn, Ralph. Notes on the Genus Aphelonema Uhler with Descriptions of New Species. Jour. Kan. Ent. Soc., July, III, p. 76, 1930.

Ball, E. D. Some New Issidae with Notes of Others. Bul. Brook. Ent. Soc., 30, p. 39, 1935.

## THE GENUS APHELONEMA 1876

### COMPARATIVE NOTES

This genus is distinguished by the following characteristics: Elongate in shape, with the sides of the body more or less parallel, head with eyes a little wider than bases of the closed tegmina; vertex sublunate or triangular with anterior margin strongly carinate; frons with prominent lateral carinae setting off a central plate which is usually much elevated above the narrower lateral compartments, each of the latter containing usually eight pustules against the lateral carina and four against the eye, although a few species have departed from this number; pronotum lunate, bluntly curved on anterior margin, posterior margin deeply sinuated; tegmina abbreviated, exposing most of the abdomen, fused together at claval margin a little obliquely rounded at apex in most species, more so in others; only one specimen of a macropterous type found by writer; venation obscure, almost obsolete in some species, a few, such as *rugosa,* with veins elevated and forming a dense reticulation; hind tibia with one apical spine.

The male genitalia of this genus are small and difficult to study. The theca seemingly completely hides the aedeagus, except for the slender, sclerotized hook of the latter.

### HISTORY OF THE GENUS UHLER 1876

Uhler (1876) described the genus with the single species *simplex* as the type species. Four other species by different authors were described under the generic names *Peltonotus* or *Peltonotellus*. These species were *A. histrionica* (Stal), 1862, *A. rugosa* (Ball), 1902, *A. bivittata* (Ball), 1902, and *A. decorata* (Van D.), 1908. Melichar, 1906, followed these writers in placing these species in the genus *Peltonotellus*, a new name given to the genus *Peltonotus* Mulsant and Rey, by Puton, in the Cat. Hemip. Palae 1886. Van Duzee in 1912 described *obscura*, which he placed in the genus *Aphelonema*. Van Duzee's Catalogue (1919) lists these six species under the genus *Aphelonema*. Metcalf (1923) in his extensive studies of eastern United States Fulgoridae keys out these six species and adds one new species, *A. rosae*. Ball (1926) described *A. nigriviridia*. Dozier (1928) adds *A. viridis*. Bunn (1930) described *A. minuta* and *convergens*, Ball (1935) described *A. orbiculata* and *A. solitaria*. In this paper the following species are described: *impercepta, concinna, confragosa* and *virgata*. The present writer considers *A. rosae* Metcalf as a synonym of *simplex*, in the belief that some secondary chemical change, perhaps, accounts for the red coloring, since touches of red show up in other species occasionally

Two color varieties have been described, *A. simplex* var. *dorsata* Ball (1926) and *A. convergens* var. *canyonensia* Bunn (1930). This makes a total of sixteen species in this genus and two varieties.

### KEY TO SPECIES

1. Vertex extremely broad, width at least five or six times median length; frons greatly exposed above, roundingly protruded as viewed from the side.... 2
   Vertex much longer, width between eyes two to three times median length; frons through middle not exposed from above, as viewed from the side either at right angles to body or distinctly receded..... 4
2. (1) Small species, length of female not over 2.55 mm., male, 1.76 mm.; central tablet of frons heart-shaped approximately one-fourth longer than greatest width.....*A. obscura* Van Duzee.
   Larger species, length of female, 3 to 3.75 mm.; males, 2.5 to 2.7 mm.; central tablet of frons subequal in width and length..... 3
3. (2) Head and thorax orange-tan, rest of dorsum blackish brown; central frontal tablet pointed below.....*A. decorata* (Van Duzee).
   Uniformly pale ochreous color; central frontal tablet almost circular.
   *A. simplex* Uhler.

4. (1) As viewed from the side head distinctly conically produced in front of eyes; frons conspicuously receded; vertex somewhat triangular, anterior margin narrowed ..... 5

Head not conically produced in front of eyes, sometimes shortened instead; frons more or less vertical; vertex with three anterior margins subequal..... 11

5. (4) Vertex triangular, median anterior margin less than length of lateral margin against eye; median frontal tablet longer than wide..... 6

Vertex not so narrowed anteriorly, median anterior margin wider than lateral margin; median frontal tablet wider than long, except *histrionica*..... 8

6. (5) Elongate, length of female, 3.4 mm.; length of male, 2.7 mm.; median frontal tablet smooth, oval, no angles indicated at either end, two pustules between tablet and postclypeus, an extra median row of 5 pustules in each lateral compartment.....*A. orbiculata* Ball.

Extremely small species, length of female under 2.5 mm.; of male under 1.9 mm.; median frontal tablet truncate at ends, only one pustule between tablet and postclypeus, the usual two rows only of pustules in each lateral compartment ..... 7

7. (6) Body slender, sides of abdomen subparallel; base of median frontal tablet roundingly narrowed, carinae continuous with no basal margin indicated.

*A. impercepta* n. sp.

Body stouter, abdomen extended at sides of tegmina; base of frontal tablet straight, about one-half the width through middle.....*A. minuta* Bunn.

8. (5) Median frontal tablet elongate, apical pustules in lateral compartment of frons, and apices of lateral carinae widely separated; tegmina and body with conspicuous yellow and black stripes.....*A. histrionica* Stal.

(Northern and Eastern)

Median frontal tablet wider than long; lateral frontal carinae joined or closely approaching each other; pale species with occasional dark markings..... 9

9. (8) Vertex longer than median length of pronotum; frontal tablet twice as wide as long, lateral carinae meeting well before apex, lateral pustules evenly spaced, forming a complete circlet across face.....*A. nigriviridia* Ball

(Eastern)

Vertex subequal to median length of pronotum, not extended; frontal tablet not over one-half wider than length, lateral pustules not evenly spaced..... 10

10. (9) Vertex about twice wider than median length; pale, robust species with a conspicuous round black spot at apex of abdomen.....*A. viridis* Doz.

(Eastern)

Vertex less than twice wider than long; longer species; a median dark stripe and lesser dark spot at apex of abdomen.....*A. solitaria* Ball.

(Southwestern)

11. (4) Pale green and yellow, no dark markings present.....*A. concinna* n. sp.

Body and tegmina stramineous, spotted or striped with dark markings..... 12

12. (11) Tegmina reticulate, veins conspicuously elevated; basal portion of postclypeus overhanging rest as a blunt tubercle (less pronounced in male).

*A. rugosa* (Ball).

Tegmina not reticulate, only 1 or 2 veins visible; no tubercle on postclypeus, 13

13. (12) A conspicuous elevated vein on clavus; costal area only of tegmen dark..... 14

No claval vein indicated; tegmina and abdomen with a broad conspicuous black stripe on each side of median yellow stripe..... 15

14. (13) Tegmina obliquely depressed through middle; black areas of abdominal segments inflated; claval vein light brown.....*confragosa* n. sp.

Tegmina not depressed; abdominal segments smooth; claval vein outlined conspicuously in black.....*convergens* Bunn.

15. (13) Five anterior sides of vertex equal; mesal black stripes of abdomen not much wider than those of tegmina.....*bivittata* Ball.

Median anterior margin of vertex longer than either the angulate or eye margin, mesal abdominal black bands at least one-third wider than those of tegmina.

*virgata* n. sp.

### *Aphelonema obscura* Van Duz. 1912

*Aphelonema simplex* var. *obscura* Van Duz., Ball (1926).
*Aphelonema simplex* var. *obscura* Van Duz., Dozier (1928).

*Comparative notes.* The writer is not able to follow Doctor Ball in placing this form as a variety of *simplex*. It is true that it falls in the so-called *simplex* group which Doctor Ball characterizes as having a round, protruding front, slightly visible from above, and a short vertex.

It is easily separated from *simplex*, however, as Van Duzee points out in the original description, by its smaller size, darker coloring, and by its ovate, oblong, distinctly narrower frons, which in *simplex* is almost circular. The difference in size is very marked, the actual measurements of *obscura* being 2.53 mm. for the length and 1.21 mm. for the width of the female, and 1.76 for the length and .88 mm. for the width of the male.

For comparison of *obscura* with *minuta, viridis* and *impercepta*, see comparative notes in the description of *minuta* Bunn.

*Male genitalia.* The harpago has the characteristic crescent shape, but in comparison with that of *simplex* is a more slender structure with the greatest width anterior to middle and the apical hook somewhat more slender.

The aedeagal structure is very distinct from that of *simplex*. In *obscura* the structure is so minute that it was difficult to get a lateral view which was not distorted. Obvious differences, however, from that of *simplex* are readily noted. In *obscura* the apical lobes of the theca are bluntly rounded, giving a boot-shape to the theca, and the theca does not seem to have the slender, curved, arm-like process which so many of the species have.

*Notes on distribution.* Described from two female specimens taken at Tifton, Georgia. Doctor Ball states that he has taken it with typical *simplex* in Kansas, Iowa, Florida and Mississippi.

### *Aphelonema decorata* (Van Duz.) 1908

*Peltonotellus decoratus* Van Duz. 1908.
*Aphelonema simplex* var. *decorota* Ball 1926.

*Comparative notes.* A robust member of the genus with sharply contrasting coloring, the head and thorax being orange-tan and tegmina and dorsum of body solid blackish-brown. Measurements, length of body, female 3.08 mm. to 3.74 mm., male 2.64 mm.; greatest width of body, 2.64 mm. In structural details closely allied to *Aphelonema simplex*, but differing by having the anterior margin of the pronotum more evenly rounded instead of forming an indistinct

angle at the inner corners of the eyes as in *simplex,* by having a shorter mesonotum, with its lateral posterior margins less oblique, and having the head slightly more extended anteriorly as viewed from the side than in *simplex.* Doctor Ball states that *simplex* has an almost circular frontal tablet, while *decorata* is usually somewhat pointed below.

*Male genitalia.* The harpago and aedeagal structure much as in *simplex,* but differing in shape, which can best be seen by examination of the drawings.

*Notes on distribution.* Type locality given as Charlotte Harbor, Florida. Specimens were at hand for study from Tampa, Sanford, Miami and Center Keys, Florida. The specimens from Center Keys were collected by R. H. Beamer on sedge, growing between reeds which at times are immersed in salt water, due to the tides.

### *Aphelonema simplex* Uhler 1876

*Aphelonema rosae* Metcalf 1923.

*Comparative notes.* A uniformly pale ochreous color, recognized by its very broad, short vertex, which allows the frons to show beyond it about the length of the vertex. The frons is convex and inclined forward. Tegmina pale yellowish translucent, with venation moderately distinct. Length of female, 3 mm. to 3.74 mm.; of male, 2.53 mm. to 2.7 mm.; width of female, 1.54 mm. to 1.98 mm.; of male, 1.32 mm.

For comparison with *obscura* Van Duz. and *decorata* Van Duz., see comparative notes in the discussion of those species.

*Color phase.* Some of the males of this species in general color are dull red, with vertex, dorsal part of frons, pronotum and mesonotum a salmon orange. Metcalf (1923) described this phase as *Aphelonema rosae* from five male specimens.

*Male genitalia.* Each harpago as viewed from a flattened lateral view is crescent-shaped, with its greatest width through middle, the apical fourth lengthened into a slender hook, which is not as long as in *histrionica.*

The aedeagus is completely hidden at its apex by the apical flaps of the theca, a slender sclerotized hook extends dorsad between the thecal flaps. The theca is tubular for its basal half, then becomes two spatulate flaps or lobes, whose shape can best be understood by studying the drawings.

*Notes on distribution.* The type locality was given as Dakota. Specimens were at hand for study from Douglas county, Kansas;

Woodside, Hartney and Red Deer River, Manitoba; Pascagonia, Mississippi; Knox, North Dakota; and Brasoria, Texas.

Dozier (1926) states that this is a widely distributed species, recorded from New Jersey, Connecticut, Virginia, Maryland, Iowa, South Dakota and Kansas.

Ball (1926) states that it is a common form from Eastern Colorado to Connecticut and New Jersey.

*Aphelonema simplex* var. *dorsata* Ball 1926

ORIGINAL DESCRIPTION

"Head and pronotum straw color continued as a broad dorsal stripe to the apex of the abdomen. This stripe often mottled with milky white. A shining black stripe from the eye back to the apex of abdomen on either side. Legs and below pale reddish, the venter often dark. Holotype, female, February 17, 1926, Sanford, Florida. Paratypes, 2 females, from same locality, March 16 and June 4, by writer.

This variety is intermediate in character between *simplex* and *decorata* and was taken with examples of the latter."

*Comparative notes.* The present writer had no specimens of this variety for study.

*Aphelonema orbiculata* Ball 1935

ORIGINAL DESCRIPTION

"Resembling *histrionica* Stal, but more definitely marked and with a round median facial tablet instead of an elongated one. Pale straw with a broad band on either side, arising on the elytra. Length, male 2.7 mm.

Vertex triangular, about equalling the pronotum, slightly more than half as long as the basal width, the angular margin three times as long as the truncate apex, instead of about equal as in *histrionica*. Frontal tablet round instead of long, egg-shaped, with the base truncate as in *histrionica*. Four pustules between the tablet and clypeus, instead of two. The lateral compartments very broad above and heavily pustulate, clypeus not inflated, rounding over into a 30° angle with the front.

Color pale straw, the frontal tablet and a broad median stripe, occupying one-third of the vertex, pronotum and mesonotum and abdomen and about one-half of the elytra ivory white. The margins of stripe and the median carina of abdomen rusty. The pustular areas on head and mesonotum dark, the pustules light. The outer

half of the elytra becoming smoky beyond the hinge and shading to black at the apex, where this color is continued as a broad lateral stripe on abdomen with the pustules white. The clypeus except base dark and the femora annulate. Holotype female from Mexico City, 1932. Paratype male, Chapultepec, Mexico. Kirkaldy in the Van Duzee Collection of the California Academy of Sciences."

*Comparative notes.* Although this writer has not seen the type of this Mexican species, it seems certain that a female specimen was taken in Socorro county, New Mexico. This specimen agrees with the description in every detail except that the broad median dorsal stripe and smoky outer half of the tegmina is only faintly indicated, where Doctor Ball speaks of them as if they were quite pronounced. This female measures 3.41 mm. in length, 1.32 mm. in width.

This species is readily separated from other members of the genus by the circular frontal tablet, with four pustules between the tablet and clypeus, instead of two, by the greatly receding frons and clypeus, by the distinctly triangular vertex, and the pronounced transverse carinae, crossing each abdominal segment. The tegmina are traversed by an irregular, only partially distinct, network of veins.

*Notes on distribution.* Described from Mexican material only. One specimen, if properly determined, taken in Socorro county, New Mexico, August 8, 1927, by L. D. Anderson.

*Aphelonema impercepta* n. sp.

*Size.* One of the small species in the genus. Length of body of female 2.42 mm., of male 1.9 mm.; greatest width of body of female, 1.1 mm.; of male, .88 mm.

*Color.* Stramineous, delicately etched in brown. Vertex stramineous, with an elongate dark spot in each lateral half, margins dark brown. Eyes stramineous. Lateral disks of frons brown, pustules yellow, central disk outlined by the dark brown carina, center smoky, median carina and line following the encircling carina yellow. Postclypeus stramineous, with a longitudinal brown stripe on each side. Gena stramineous, antennal socket encircled by a brown ring. Pronotum light fuscous tan, pustules faintly outlined in yellow. Tegmina translucent stramineous, veins slightly darker. Abdomen stramineous with traces of fine longitudinal stripes visible on each side, the two median ones more pronounced and outlining a narrow yellow stripe between them. Underside of body stramineous, except a faint longitudinal brown band across pleural pieces, starting with the spot on the gena and continuing more or less interruptedly across abdomen. Ovipositor dark brown. Legs yellow, faintly

spotted, with dark tips of claws black. Male specimens somewhat darker.

*Structural details.* Vertex distinctly triangular, more so than in most species, the anterior margin less in width than length of eye margin, greatest width across base about twice the median length. Length of pronotum at middle only a little greater than median length, a median carina distinct, space between it and eye occupied by large pustules in rows of five, four, and three. Mesonotum with a prominent median carina, two lateral carinae less pronounced than in other species, each lateral third containing about eight large pustules. Frons with total length and width subequal, the central disk or compartment smoothly oval, the lateral carinae completely encircling it, length of this disk over one-third longer than width, basal margin greatly narrowed, being only one-third or less of width at middle; each lateral compartment of frons bearing large pustules, the customary eight against the carina with one between apical marginal carina and postclypeus and four against the eye. From side view head distinctly angled above, postclypeus not inflated, greatly receded. Tegmina smooth, moderately short, latero-apical corners roundingly cut off, four distinct longitudinal veins present. Abdomen with distinct dorsal carinae on each side following the anterior border, immediately followed by transverse rows of five or six small pustules, transversely depressed posterior to pustules.

*Male genitalia.* The harpago in this species seems to have its apical hook sharply recurved against the rest of the structure. Only one male specimen was available for dissection so that the author was unable to determine whether this was an artifact. Both harpagones were bent in the same way.

The aedeagal structure was so minute that few details could be made out. The usual sharply pointed, sclerotized hook extended externally between the flaps of the theca, the rest of the aedeagus being entirely hidden. The theca terminates in two blunt, short flaps.

*Comparative notes.* This species resembles *minuta* Bunn, *obscura* (Van Duz.) and *viridis* Doz. For comparison of these four species see the comparative notes in the description of *minuta* Bunn.

*Geographical notes and notes on types.* Holotype male, collected by R. H. Beamer from the Santa Rita Mountains, Arizona, on August 18, 1935. Allotype female, same place and collector, on August 17, 1932, and one male paratype. Twelve paratype females, same data as holotype. These types are in the Snow Entomological Collection, University of Kansas.

### *Aphelonema minuta* Bunn 1930

*Comparative notes.* A small species measuring 2.2 mm. in length for female and 1.1 mm. for greatest width of body. In coloring the species is a pale tan, speckled indistinctly with brown, especially on lateral disks of frons and on the abdomen, where three indistinct darker longitudinal stripes are indicated.

*Minuta* Bunn in size, coloring and general appearance more closely resembles *obscura* (Van Duz.), *viridis* Doz., and *impercepta* Ball. These four species are easily separated by the shape of the frons and the vertex. In *minuta* the anterior median margin of the vertex is one-half the length of one oblique lateral margin and the width is three times its median length; in *obscura* this frontal margin is twice wider than on oblique lateral margin and the vertex is six times wider than its median length; in *impercepta* the median anterior margin is less than one-third of an oblique margin and the vertex width is twice the median length; in *viridis* the median anterior margin is equal to one oblique lateral margin and its width is not quite twice the median length.

The median frontal disk of *minuta* has its length at middle, a trifle longer than the width and the basal margin approximately one-half of its greatest width; in *obscura* the disk is one-third longer than wide and its basal margin is about two-thirds of its width; in *impercepta* the length of the disk is over one-third longer than the width, and the basal margin is greatly narrowed, being only one-third or less of the width at middle; *viridis* has the widest disk, at middle measuring less than its median length and its anterior basal margin is about two-thirds of its length.

*Notes on distribution.* Described from three females, collected at Cochise, Arizona, in 1927. No other specimens were available for study from which to make genitalia slides.

### *Aphelonema histrionica* (Stal) 1862

*Peltonotus histrionica.*
Stal, Carolus.

ORIGINAL DESCRIPTION

"Oblongus, pallide grisco-stramineus; vitta latiuscula verticis, thoracis scutellique allrida, utrimque nigro-marginata; frontis areis lateralibus, clypeo, thoracis scutellique lateribus, lineis duabus mediis vittaque utrimque laterali dorsi abdominis, pectore ad partem, ventre, maculis pedum basim femorum nigris; lateribus nigris frontis, thoracis scutelloque pallido-granulatis; vittis lateralibus abdominis pal-

lido-variegatis; tegminibus multo abbreviatis, albidis, fuscobivittas. ♂ -Long. 4⅔, Lat. 1⅔ millim.

Caput cum oculis thorace paullo latius, vertice ante oculos producto, transverso, longitudine paullo plus duplo latiore; fronte a medio sursum levissime, apicem versus distincte augustata, tricarinata, carinis lateralibus arcuatis, areis lateralibus obliquis. Thorax subsemiorbicularis, basi latissime emarginatus, medio leviter carinatus. Scutellum tricarinatum, carinis parallelis."

REVISED DESCRIPTION

*Size.* Length of body from apex of head to apex of abdomen for female, 3.5 to 4.4 mm.; for male, 3 mm. to 2.86 mm.; greatest width of body midway of abdomen in female, 1.54 to 1.76 mm.; in male, across tegmina, 1.11 to 1.46 mm.

*Color.* General ground color stramineous yellow, conspicuously striped and spotted with dark. Eyes dark brown. Vertex yellow, raised lateral margins in black, in each lateral third an irregular brown stripe which enlarges considerably near caudal margin. Central disk of frons yellow mottled in pale brown, lateral carinae broken into seven black dashes alternated with yellow, lateral disk with yellow pits, surrounded by blackish-brown, leaving a yellow streak down center. Gena yellow except for black margins around eye and antennal socket. Antenna black. Clypeus pitch black. Pronotum with a broad yellow stripe down middle adjoining a similar one on vertex and mesonotum. This pale stripe margined on each side with a narrow dark stripe, rest of each lateral third light brown, slightly darker just inside of raised yellow margin, the thin carinate margins dark. Mesonotum yellow inside of lateral carinae, except for two brown streaks, contiguous with those of pronotum; each lateral third brown, except for a yellow circle around each brownish pit. Abdomen above with five dark stripes, the median one narrow, the others broad and irregularly interrupted. Tegmina semiopaque, a broad brownish stripe on costal border, another false stripe, usually indicated through middle of corium, due to an abdominal stripe showing through the tegmen. Thorax below mostly yellow, spotted in black. Abdomen below mostly black. Legs dark to black, especially basal half of femur, rest speckled in light.

*Structural characteristics.* Head with eyes wider than thorax. Vertex two-thirds wider than length through middle. Frons about equal in length and width, a distinct median carina present, the lateral carinae outwardly bowed so that the middle plate in length is two-fifths greater than its width, deflexed ventrad, forming an

acute angle with vertex; postclypeus short, forming an obtuse angle with the frons. Pronotum, forming a lunate disk between the eyes, with seventeen round raised pits in each lateral third, at extreme sides greatly reduced by the overlapping of the eye to a narrow arm, then widening again into a spatulate lobe below the posterior half of the eye. Mesonotum with a distinct median carina, and prominent lateral carina only slightly curved. Tegmina in female with greatest length approximately equal to length of abdomen exposed beyond their apex, in male proportionally longer due to the dovetailing of the posterior segments; venation simple, only four longitudinal veins visible and scarcely any or no reticulation. The ninth segment bears a short, blunt, fingerlike extension which curves around the apex of the harpago.

*Male genitalia.* Each harpago as viewed from a flattened lateral view is a narrow hooklike structure in the form of a crescent with its dorsal margin finely serrate from about middle to apex.

The aedeagal structure because of its small size is difficult to place in exact lateral view for drawing. The aedeagus itself is a sclerotized tube ending in two recurved sharp hooks, one much shorter and usually entirely hidden by the theca, the other tapering into a long, sharp pointed hook, projecting ventrad between the lobes of the theca. The theca is bilobed at apex, each lobe on its dorsal apical margin prolonged into a short pointed extension.

*Notes on distribution.* Doctor Ball (1926) states that this species apparently goes from coast to coast in the northern part of the United States. He found it at an altitude of 10,000 feet back of Ward, Colorado. The present writer had specimens for study from the following places: Merritt, British Columbia, Shoal Lake, Russell and Cowan in Manitoba, California, Colorado, Michigan, Minnesota, Montana, New Hampshire, New Mexico, and Wisconsin. Other records given are Iowa, New York, Massachusetts, and Nevada.

### *Aphelonema nigriviridia* Ball 1926

*Comparative notes.* This species is an elongate, greenish or straw-colored species, with black markings. It is unique in structure for the genus. Its outstanding characteristics are the long and angular vertex, which is definitely longer than the pronotum, and its peculiar conical head. In lateral view the frons extends anteriorly a great distance beyond the eyes, the lateral carinae are greatly curved and meet the median carina at middle, thus carrying the circular pustules near the latter so that they form a complete circlet across the

face. The disk of the frons thus enclosed by these carinae is wider than long, which is not true for the majority of species, except *viridis* and *solitaria*.

Doctor Ball (1926) states that this forms a third group in the genus Aphelonema and that it is closely related to some South American forms that have been placed in the genus *Plagiopsis* Berg. It may be that with greater study of tropical species that this species belongs in some other genus than that of *Aphelonema*.

Measurements in size are as follows: length of female is 3.08 mm., and greatest width 1.21 mm.; length of male is 2.2 mm. and its width .88 mm.

There is some difference in coloration in the sexes. The male has a broad shining black stripe extending from the upper part of the front across the eyes and including the outer third of the elytra and abdomen in sharp contrast to the pale yellow median band. The female is pale, with the lateral stripe on each side interrupted and only faintly indicated and the carinae and veins etched in light brown.

*Male genitalia.* Each harpago in flattened lateral view is typically crescent-shaped, broadest through middle and the apical third extended into a slender hook.

The aedeagus is covered by the theca, which does not have as long apical lobes as in some species and is serrate along its dorsal margin as is seen from a lateral view. A long, slender curved process of the aedeagus curves anteriorly.

*Geographical distribution.* The type locality is given as Sanford, Florida, where Doctor Ball states that it is found only in the wetter portions of the "flat woods" and along the margins of swamps.

Specimens have been collected at Key Largo and Homestead, Florida. It is not an abundant species as represented by collections.

### *Aphelonema viridis* Dozier 1928

*Comparative notes.* This species somewhat resembles *nigriviridia* Ball. It differs, however, by having a shorter, stouter body, which measures in length 2.42 mm. for female and 1.98 mm. for male; in width, female 1.21 mm. and .88 mm. for male; by having a shorter, wider vertex, which in *nigriviridia* is definitely longer than the pronotum, while in *viridis* vertex and pronotum are subequal; by the frontal disk being only approximately one-third wider than long, while in *nigriviridia* it is one-half wider.

The color of this species is distinctive. The female is a pale green with dark eyes and two small black spots on the last two abdominal

segments along the median keel. The male differs by having a rosy-orange color.

For comparison of this species with *obscura, minuta* and *impercepta,* see comparative notes under the description of *minuta* Bunn.

*Notes on distribution.* Type material came from Hattiesburg, Ocean Springs, Hurley, and Wade, Mississippi, taken by sweeping grass in low pine land.

*Aphelonema solitaria* Ball 1935

*Comparative notes.* A greenish or stramineous species, the female measuring in length, 2.86 mm. to 3 mm.; in width, 1.21 mm. to 1.32 mm. It is, therefore, larger than *viridis* Doz., which is one of the best characters for separating the two, and a trifle smaller than *nigriviridia* Ball.

This species resembles *viridis* Doz. and *nigriviridia* Ball. It is separated by size as indicated above and by color differences. *Solitaria* has traces of five brownish stripes on abdomen, the median one distinct, ending in an enlarged dark spot at apex, the lateral stripes more or less interrupted, whereas *viridis* is greenish-yellow with no stripes, only the apical spot, indicated, and *nigriviridia* has more conspicuous abdominal stripes and a transverse brown band on frons. Structurally the species is separated by the vertex, which is not twice wider than its median length, as it is in *viridis,* but is not as long as in *nigriviridia,* where its width is only two-fifths wider than median length. The central tablet of the frons is proportionally longer, being only one-fourth wider at middle than its median length in *solitaria,* but about one-third wider in *viridis* and about two-thirds wider in *nigriviridia.*

*Notes on distribution.* Described from one female from Madera Canyon, Santa Rita Mountains, Arizona, and one male, east side of Santa Rita Mountains. The writer had a series of seven females for study from the same region.

*Aphelonema concinna* n. sp.

*Size.* A small, pale-green species. Length of female from apex of head to tip of abdomen, 2.65 mm. to 3 mm.; greatest width of body, 1.21 mm. to 1.32 mm.

*Color.* The most delicately colored species in the genus, pale green and yellow with no dark markings. Vertex, pronotum and mesonotum light yellow through middle, lateral areas pale green, pustules pale. Eyes brown. Frons pale yellowish-green, centers of median and lateral disks partially hyaline, areas next to margins

and outlining the carinae opaque. Postclypeus with a median stripe and two spots on each side light green, rest pale yellow. Underside of thorax pale green. Legs mostly light yellow, tibiae sometimes green, claws brown. Abdominal segments green, except posterior margin, which is distinctly yellow. Ovipositor washed in brown. Tegmina uniformly pale yellow.

*Structural details.* Vertex broad, depressed, median anterior margin broader than the angulate and eye margins, which are equal. Frons pear-shaped, lateral carinae sharply elevated, outlining an oval central compartment, apical ends almost touching, each lateral compartment about one-half width of central one. A median carina arising on ventral half of frons and extending across postclypeus; postclypeus and anteclypeus not inflated, rounding over into about a 30° angle with frons. Pronotum rounded deeply into head, midline equal to length of vertex at middle, at sides eyes inserted almost to posterior border; each lateral third of dorsal plate with 24 pustules, lateral flap below eye with anterior margin angulate, a transverse carina indicated behind eye and one pustule present just below this against posterior margin. Mesonotum with sharply elevated lateral carinae, which narrow somewhat at apex, each lateral compartment containing 20 pustules. Tegmina squarely truncate, the apico-costal corner only slightly cut off; venation very indistinct, a partial claval suture indicated and a forked vein faintly visible on corium. Abdominal segments above with posterior margins thickened, pustules arranged as in drawing.

*Comparative notes.* Not easily confused with anything else in the genus because of its distinct coloring, lacking any dark markings. It might at first glance, because of its size, be confused with *viridis* Doz., *minuta* Bunn and *impercepta* n. sp. It is separated from *viridis* by having an elongate frontal tablet and from *minuta* and *impercepta* by its broad vertex, which in these species is somewhat triangular.

*Geographical distribution.* Described from eight female specimens. Holotype female, taken August 8, 1936, by R. H. Beamer, at Las Vegas, Nevada. Seven paratype females, same data. These types in the Snow Entomological Museum, University of Kansas.

### *Aphelonema rugosa* Ball 1902

*Comparative notes.* This species resembles *histrionica* more than any other species. It is separated from the latter by having a shorter vertex, as the three anterior margins are subequal, while in *histrionica* the anterior lateral margins are much longer than the

anterior middle section. *Rugosa* also has a reticulate venation, with the veins conspicuously elevated. This species is moderately slender, measuring 3.00 mm. to 3.75 mm. in length and 1.55 mm. to 1.76 mm. in width for females; for males, 1.9 mm. to 2.4 mm. in length and 1.1 mm. to 1.21 mm. in width.

A valuable characteristic for distinguishing this species from all others in the genus, which is usually quite prominent, is the nature of the postclypeus. Here the basal portion overhangs the rest in the form of a bluntly-pointed tubercle, especially noticeable in side view.

The essential features of coloration are quoted from the original description as follows: "gray or fuscous maculate, a broad, pale median stripe on vertex, pronotum and scutellum, margined by four pairs of black dashes, vertex with a pair of ocellate spots at base, and the margins mostly dark lined; front pale yellow, sometimes irregularly washed or marked with dusky, lateral compartments black with the pustules white; clypeus black, base and a line down to the apex of the tubercle light; lateral areas of pronotum and scutellum dark, with pustules light; elytra brownish fuscous, nervures light, abdomen above with a narrow median and three pairs of lateral stripes, the two outer pairs broad and pustulate."

*Variation.* In a long series of this species there is considerable variation. At one extreme are those forms which have a less pronounced tuberculate postclypeus and less elevated wing veins, sometimes the tegmina being almost smooth. A decided color variation is found in some of the males which show on each tegmen a wide oblique costal stripe down middle and a broad creamy band across vertex and thorax in sharp contrast.

*Male genitalia.* Each harpago as viewed from a flattened lateral view is crescent-shaped, broadest through base of basal third and serrate-margined on dorsal apical third.

The ninth segment bears a fingerlike extension, which is longer and more tapering than that of *histrionica*.

The aedeagus is almost entirely hidden by the theca. The theca ends in two truncate lobes with the dorsal margins of these lobes more or less parallel, not prolonged into pointed extensions.

Notes on distribution. The type locality is Colorado. Specimens were available for study from the following places: Kansas, Scott county, Republic county, Harper county, Sherman county, Riley county and Cheyenne county, Spearville, Reno county, Phillips county, Smith county, Norton county; Minnesota, Itasca Park; Colorado, Lindon, Durango, Parshall, Montrose, Fort Collins, Ma-

sonville, Craig, Pagosa Springs, Pawnee Buttes; Utah, Barclay, Soldier's Summit; Wyoming, Bozler, Wheatland, Lingle; Idaho, Hollister, Burley; Washington, Naschez, Cliffdell, Toppenish; Oregon, Grants Pass; California, Anza, San Jacinto and Laguna Mountains; Arizona, Cochise, Pearce, Ashfork; Oklahoma, Waynoka; New Mexico, Belen, Taos county, Alamagorda, Chaves county; Texas, Pecos, Fort Stockton, Seymour, Canyon, Potter county and Amarillo.

*Apheloncma confragosa* n. sp.

Original Description

*Size.* A robust species, measuring in length for female 2.85 mm. to 3 mm., for male 1.75 mm. to 2 mm.; greatest width of body for female, 1.54 mm., and for male, 1.1 mm.

*Color.* A striking species in contrasting cream yellow and black, resembling *convergens* Bunn. Vertex cream yellow with extreme margins etched in dark brown and a conspicuous dark brown roundish spot in each lateral half against pronotal margin. Eyes dark brown, outlined in yellow. Frons uniform yellow with pustules, the lateral basal margins and the lateral carinae for half their length etched in brown. Clypeus in median basal region light, rest dark brown. Segments of antennae and an irregular band beginning at middle of eye and extending to apical corner of frons dark brown. Lateral disks of pronotum dark, pustules yellow; median disk yellow, with brown carinae etched in dark brown. Tegmina yellow except for the conspicuous claval vein which is broadly outlined in reddish-brown, and a blackish brown area across the posterior lateral corner. Abdomen from above cream yellow with a conspicuous broad shining black stripe on each side, the two black stripes outlining a median yellow band of equal width, the extreme lateral third of each segment bearing three dark dashes, the medial one of the three being the longest. Thorax from below yellow except for a cloudy dark band crossing the base of the mesothorax, coxa and pleural sclerites, thus forming a continuous oblique band with the dark costal band of the tegmen. Abdominal segments dirty yellow clouded with fuscous at the sides. Ovipositor yellow, clouded with fuscous. Legs yellow, femora with irregular patches of reddish-brown, tibiae streaked with brown, tarsi washed in dark brown, becoming darker towards apex.

*Males.* Similar to females in coloration except that the median yellow stripe on the abdomen is greatly narrowed and the legs are orange to red in color.

*Structural characteristics.* Head wider than prothorax. Vertex

at greatest width twice wider than greatest length, the five angulate margins about equal in width, the lateral angle in line with the anterior margin of eye so that the vertex is not greatly protruded forward. Forms elongate, its greatest length one-fourth longer than greatest width; lateral carinae greatly elevated, setting off a narrow central disk which at middle is about one-half of its length, a median carina indicated only on lower half of central disk; eight small pustules in lateral disk lying against the lateral carina and four next to eye. Postclypeus not inflated, rounding over into a 30° angle with the frons. Pronotum at middle one-fourth longer than median length of vertex, lateral margins next to eye greatly elevated, deeply convex at middle, twenty-one pustules on each side mesad of eye in rows of seven, six, five and three, respectively. Mesonotum conspicuous with a more or less rectangular area outlined through middle with the raised lateral carinae forming the side boundaries and a transverse carina the anterior boundary, the lateral disks heavily pustulate. Tegmina abbreviated, truncate at apex with outer costal angle rounded, giving a distinctly ovate shape to each tegmen as viewed from above; the longitudinal vein of the claval region elevated and very conspicuous, joined near apex by the inner branch of a forked vein of the corium, no veins indicated between these two main veins, the area between them distinctly depressed. Terga of the abdominal segments transversely depressed except where crossed by the shining black band which is somewhat inflated.

*Male genitalia.* Each harpago in flattened lateral view somewhat more slender than related species. The ventral hook of the ninth segment smaller and of a different shape than in *bivittata*. (See diagrams.)

The thecal-aedeagal structure of the bivittata type, but differing distinctly from it by having the thecal flaps roundingly bulged at the dorsal posterior angle instead of obliquely cut off as in *bivittata*. The aedeagus entirely hidden by the theca but a slender, sclerotized process indicated along its dorsal side.

*Comparative notes.* This species more closely resembles *A. convergens* Bunn, *A. bivittata* (Ball) and *virgata* n. sp. The color patterns of all four species are different and can be used in distinguishing them. *Bivittata* and *virgata* are easily separated structurally by lacking the conspicuous elevated claval vein which the other two have. The tegmina of *confragosa* is furthermore distinctive from the rest by having the apico-costal corners greatly cut off, giving the tegmina a distinctly ovate shape instead of the wedge

shape type of the others and having the middle region of each tegmen deeply depressed. The shape of the vertex in the four species differs somewhat in the different species. On *bivittata* the vertex is narrower than in the other three, its width being only a little more than twice its median length while in the others the width is almost three times greater and the five anterior margins are all equal. In *convergens* the vertex seems proportionally longer since the lateral margins next to eyes are shorter than the angulate margins in front of them while the median anterior margin is widest of all. In *virgata* the median anterior margin is wide as in *convergens,* but the angulate and eye margins are equal in length, thus shortening the amount of vertex anterior to eye. In *confragosa* the margin against eye is longer than either the angulate or median margin and the latter two are equal in length. The four species show differences in regard to the frons as follows: *convergens* has widely separated lateral carinae so that the median compartment at middle is about three times the width of one lateral compartment; in *confragosa* the middle compartment is narrower than in other species with a lateral compartment measuring in width at middle one-half or more of the width of the median compartment, the black stripes along the lateral carinae are lacking and a median carina is distinctly indicated on apical half, in *bivittata* and *virgata* each lateral compartment is one-half of the width of the median compartment, but the two species are separated by *virgata* having a larger postclypeus than *bivittata* has.

*Location of types and distributional notes.* Holotype male and allotype female, collected in the Mustang Mountains, Arizona, June 12, 1933, by R. H. Beamer. Five paratype females and eight paratype males same data. One female paratype collected by R. H. Beamer at Tucumcari, New Mexico, June 4, 1933. These types in the Snow Entomological Museum, University of Kansas. Seven female paratypes and twenty-seven male paratypes, collected by Paul Oman in the Mustang mountains, Arizona, June 20, 1933, and two female and two male paratypes, same collector from the Santa Rita Mountains, Arizona, June 12, 1933. These paratypes in the National Museum, Washington, D. C.

*Apheloñema convergens* Bunn 1930

Ball (1935) as bivittata Ball.

*Comparative notes.* A black and yellow striped species closely resembling *bivittata* Ball. It differs in color from *bivittata* by having the oblique yellow lines of the tegmina converging at mesocaudal angles and not continuous with abdominal stripes.

Structurally *convergens* can be separated from *bivittata* in several ways. In *convergens* the vertex is extended considerably beyond the eyes so that the latero-anterior angle is in line with the anterior margin of the eye and none of the frons is visible from above while in *bivittata* the anterior margin of the vertex is in line with anterior margin of the eye and the frons is usually indicated from above. Another distinguishing feature is the shape of the pronotum. In *convergens*, the anterior margin between the eyes is straight, the carina of the vertex in front of it is more pronounced, the lateral margins mesad of the eyes are greatly elevated and the posterior margin is not deeply emarginate at middle. In *bivittata* the anterior margin is distinctly rounded and the posterior angulately emarginate at middle with the lateral margins not greatly elevated. The most easily recognized structural difference is the venation of the tegmina; in *bivittata* the longitudinal veins are scarcely visible while in *convergens* a single claval vein is very distinct and elevated, even to the extent of looking like a carina outlined in black; while in the corium a distinct but less pronounced forked vein starts near the costal border and has its inner branch extending to the apex of the tegmen.

In size *convergens* seems to average slightly larger than *bivittata,* the females measuring 3 mm. in length and about 1.54 mm. in greatest width, while the males average 2 to 2.25 mm. in length and 1.2 mm. in width.

*Male genitalia.* There are distinctive differences between *bivittata* and *convergens* in these structures. The ninth segment of *bivittata* shows in situ a fingerlike extension on each side of the genitalia (see drawing). This is lacking in *convergens.* The shape of the harpago in flattened view is different in the two species (see diagrams).

The apical flaps of the theca show greater differences than those of more greatly dissimilar species. In *convergens* the dorsal angles of the thecal flaps are posteriorly directed knobs while in *bivittata* they are more angulate and directed forward.

*Notes on distribution.* Holotype, allotype and five paratypes from Cochise county, Arizona, and 6 paratypes from Colfax county, New

Mexico. Available for study for this paper was a long series from the Santa Rita Mountains, Arizona. A few scattered specimens from Phoenix and Flagstaff, Arizona, and Monument, Colorado.

*Aphelonema convergens var. canyonensia* Bunn 1930

This variety is not as distinct a color difference as is usually true for varietal forms. Bunn states that a distinct yellow replaces the greenish yellow of the typical form and that the two black stripes just mesad of the lateral carinae of the scutellum are wider and tend to be continued across the pronotum and vertex as a continuous stripe.

This difference of coloration is of course more pronounced when extremes of both forms are being compared, true *convergens* having distinctly whitish light areas and *canyonensia* distinctly yellow yet many specimens are found where these differences are slight and makes it confusing which variety to call them.

*Aphelonema bivittata* (Ball) 1902

As *Peltonotellus bivittatus.*

*Comparative notes.* A medium sized species of *Aphelonema,* measuring 2.4 mm. to 3 mm. in length for the female and 1.3 mm. in width; for the male, 2.2 mm. to 2.35 mm. in length and 1.1 mm. in width. It is easily recognized by its striped color, having a broad dorsal yellow stripe running from vertex to tip of abdomen, a pair of oblique lines under the eyes and meeting the median line on the last abdominal segment yellow, the frons greenish-yellow with the lateral carinae black in sharp contrast, the lateral carinae of mesonotum and a pair of stripes within them black.

The outstanding structural features are the six-sided vertex with the anterior and lateral margins equal, and the narrow, elongate middle plate of the frons which is about twice as long as width through middle. The ninth segment has a fingerlike projection which hooks around the tip of each harpago. This shows only faintly in ventral view, but from a flattened view on a microscope slide shows as in figure.

*Male genitalia.* The harpago in flattened view has a characteristic shape, differentiated from that of other species by having a distinct bend near the apex so that the slender apical hook is almost at a right angle to the median portion.

The apical flaps of the theca are narrowed on dorsal region forming rather backward projecting rounding points. The aedeagus is

practically hidden by the theca except for a slender, backward projecting hook.

*Notes on distribution.* This species was described from specimens taken in Colorado, Nebraska, Kansas and Iowa.

The writer had specimens for study from Cheyenne and Jewell counties, Kansas, Las Animas county, Colorado, Apache county, Chiracahua Mountains, Faraway Ranch and St. Johns, Arizona, Wichita, N. F., Oklahoma and Blue Springs, Colfax county, and Socorro county, New Mexico.

Doctor Ball (1935) states that this species is found more abundantly in Arizona than in the plains region from which it was described. Also he makes the observation that it becomes highly variable in the tropics and hence the color variations are numerous among these species.

### *Aphelonema virgata* n. sp.

#### ORIGINAL DESCRIPTION

*Size.* Length of body of female, 2.64 mm. to 3.22 mm.; of male, 2.12 mm.; greatest width of body of female, 1.32 mm. to 1.76 mm., for male, 1.25 mm.

*Color.* A yellow-and-black striped species, resembling *bivittata.* Head yellow, etching along margin of vertex and an oval spot on each lateral disk against pronotal margin blackish-brown. Eyes black. Front yellow, lateral carinae outlined their full length with a broad, black stripe, a small dark spot along lateral basal margin and an irregular one at latero-apical angle. Clypeus blackish-brown except a basal light area in the shape of an inverted bell. Gena yellow with an oblique, irregular, black stripe beginning at eye and running to epistomal suture. Pronotum yellow with lateral margins mesad of eye etched in brown, pustules pale brown, a black border, encircling eyes. Mesonotum with a broad median stripe, a narrow stripe on each side of the lateral carina and pustules yellow, rest black. Tegmina with claval margins broadly yellow, together forming a median yellow stripe continuous with one on abdomen, a broad oblique yellow band in each tegmen, starting at base of costal border and ending midway of apical border. Abdomen from above black except for a distinct median yellow stripe and four interrupted, less conspicuous paler stripes on each side. From below thorax yellow, except pleural pieces of meso- and metathorax, which are shining blackish-brown, forming an oblique line with the dark outer angle of the tegmen. Sterna of abdomen and ovipositor blackish-brown

except occasional inconspicuous lighter spots. Legs yellow, variously marked with brown, the more conspicuous marks being a brown spot at base of mesothoracic coxa, a spot at base of each femur and two semicircular brown spots near the apex, tibia darker yellow streaked in brown, tarsi washed in brown, clavus black.

*Structural details.* Head approximately same width as prothorax. Vertex transverse, about one-third wider than median length, not extended greatly beyond eyes, the lateral angle in line with anterior margin of eye, the three anterior margins subequal and longer than lateral margin against eye. Frons elongate, its greatest length one-fourth longer than greatest width, the lateral carinae greatly elevated, the central disk equal in width at base and apex, at middle twice wider than one lateral disk, the latter greatly depressed; no median carina indicated; in each lateral disk eight pustules following the lateral carina and four lying against eye. Postclypeus slightly inflated, forming slightly less than a forty-five degree angle with frons, anteclypeus considerably recessed.

Median length of pronotum one-fourth longer than that of vertex, concave through middle, nineteen pustules in each lateral disk starting at eye arranged in rows of six, five, five, and three, at extreme sides almost covered by eye, then expanded ventrad into a spatulate lobe which extends forward almost to antenna and bears only one pustule near its posterior margin. Mesonotum three-fourths wider than long, concave through middle, lateral carinae sharp and conspicuously elevated. Tegmina truncate, apico-costal corners roundingly cut off but not as much as in certain species, the claval vein faintly indicated at base only, an indistinct branched vein in corium. Abdominal segments smooth in contour, only slightly depressed at sides.

*Male genitalia.* Ventral hook of ninth segment larger than in related species, roundingly pointed. Each harpago in flattened lateral view not greatly widened through middle, its apical hook extremely slender and bent almost at right angles.

Theca-aedeagal structure characteristic, the aedeagus entirely hidden by the theca, the thecal flaps blunt, rounded at apex with their dorso-anterior corners fitting snugly against the basal tube.

*Comparative notes.* This species resembles *bivittata, convergens, confragosa* and *virgata.* For comparison of these four species, see notes under *confragosa.*

*Location of types and distributional notes.* Described from allotype female, taken at Silver City, New Mexico, July 23, 1936, holo-

type male, Las Vegas, New Mexico, July 18, 1936, 1 paratype female, Silver City, New Mexico, July 23, 1936, 2 paratype females, same place, July 22, 1936, 1 paratype female, Las Vegas, New Mexico, July 18, 1936. These types collected by R. H. Beamer and deposited in the Snow Entomological Museum, University of Kansas. Two paratype females and 1 male, collected by Paul Oman, June 24, 1933, from Patagonia, Arizona. These types in the National Museum, Washington, D. C.

## *Fitchiella* (Fitch) Van Duzee 1856

Fitch, Asa. Trans. N. Y. St. Agric. Soc. XVI, p. 396. As *Naso*.

Melichar, Leopold. Monograph der Issiden (Homoptera). Abh. K. K. Zoöl. Bot. Ges Wien III, p. 4, 1906. As *Naso*.

Ball, E. D. New Genera and Species of Issidae (Fulgoridae). Proc. Biol. Soc. Wash. XXIII, p. 42, 1910. As *Naso*.

Lawson, Paul B. The Genus Fitchiella (Homoptera, Fulgoridae). Bull. Brooklyn Ent. Soc. XXVIII, No. 5, pp. 194-198, 1933.

### COMPARATIVE NOTES

This genus is similar to *Bruchomorpha*, especially the long-nosed species of the latter. It is most readily distinguished by the expanded fore and middle tibiae except in *robertsoni* where it is nearly normal. Other outstanding characteristic is the long head process which frequently is bulbous at the end. In the lateral compartments of the frons are eight circular pits against the lateral carinae and four against the eye. The vertex is broad and short, usually six to eight times its median length. Tegmina short, veins distinct, claval region rugulose. Hind wings lacking.

### HISTORY OF THE GENUS

Fitch in 1856 described the genus as *Naso*, with *robertsoni* as the type. Van Duzee in 1917 changed the genus name to *Fitchiella*, as *Naso* was preoccupied. In 1906 Melichar described *fitchi*. In 1910 Ball described *melichari*. In 1933 Lawson described five additional species, namely, *F. albifrons*, *F. rufipes*, *F. grandis*, *F. minor* and *F. mediana*. The present writer did not have available for study *F. melichari*, *F. grandis* or *F. minor*, but the original descriptions are herein given.

Several of the species in the genus are not easy to identify, especially the so-called *melichari* series, which includes *melichari grandis*, *minor* and *mediana*. However, this writer believes that five species are sufficiently distinct when carefully studied, namely, *F. robertsoni*, *F. fitchi*, *F. albifrons*, *F. rufipes* and *F. mediana*. The harpagones as viewed from a side view are easily distinguishable and add another character to those given by Lawson for separating these

five species. Larger series of all the *melichari* series are needed before one can feel very certain as to the validity of two or three of the species. Of all the eight species, *F. fitchi* seems to be the only one taken in any great numbers.

### KEY TO SPECIES

(Based on Lawson's key)

1. Head process transversely depressed through middle, knobbed at apex; light species marked with black ..... *F. robertsoni* Fitch, p. 209
   Head process not particularly depressed; brown to black species ..... 2
2. (1) A large mottled brown species, females measuring over 4.6 mm. in length; males half this length; lateral frontal carina deeply scalloped .. *F. fitchi* Melichar, p. 210
   Mostly black species, females measuring 4.25 mm. or under ..... 3
3. (2) Frons with longitudinal white stripe; harpago slender, three times longer than width through middle ..... *F. albifrons* Lawson, p. 211
   Frons entirely dark ..... 4
4. (3) Venter of head process and most of legs reddish; harpago stout, less than twice longer than width at middle ..... *F. rufipes* Lawson, p. 211
   Venter of head process black and legs (except in *minor*) usually entirely black, 5
5. (4) Head process very large and quadrate apically ..... *F. grandis* Lawson, p. 213
   Head process smaller and rounded apically ..... 6
6. (5) Head process quite short; fore tibiae reddish ..... *F. minor* Lawson, p. 213
   Head process longer; fore tibiae usually dark ..... 7
7. (6) Head process longer; fore tibiae very wide ..... *F. melichari* Ball, p. 210
   Head process shorter; fore tibiae narrower; harpago over twice longer than width through middle, apical hook lengthened to a fine point.
   *F. mediana* Lawson, p. 212

## *Fitchiella robertsoni* (Fitch) 1856

### COMPARATIVE NOTES

This species is a unique species for the group in that it does not have the greatly expanded fore and middle tibiae. For that reason it might easily be taken for a *Bruchomorpha*. It differs from this group, however, by having a long bulbous nasal process and the fact that the fore and middle tibiae are a trifle expanded. It is strikingly colored, having a tan background with conspicuous dashes on the abdominal terga, the cells of the tegmina, two roundish spots on mesonotum, vertex and central disk of frons, all dark brown to black, and the bulbous end of the nasal process shining black. The vertex is much longer in this species, being not over three times wider than median length. It also differs by having the lateral carinae of the frons converging considerably posterior to apex and by having the frons deeply depressed across middle. Length of female, 4.4 mm.; greatest width, 1.76 mm.; length of male, 2.86 mm., greatest width, 1.1 mm.

*Male genitalia.* The harpago in flattened lateral view is distinctive. Its greatest width is through the base, from which point it gradually narrows down to the curved tapering apex.

The aedeagus is mostly hidden by the theca, so that it is difficult to distinguish anything but the sclerotized recurved hook which protrudes between the apical flaps of the theca. See drawing.

*Notes on distribution.* Dozier states that it is recorded from New York, Maryland, Florida, Indiana, Kansas, Arkansas, Oklahoma and Texas. He adds Mississippi.

### *Fitchiella fitchi* (Melichar) 1906

#### COMPARATIVE NOTES

This is a large species, measuring 4.6 mm. to 5 mm. in length for female; for greatest width of female, 2.4 mm.; for male, 1.1 mm. It is easily distinguished by its large size, conspicuous coloring, which consists of a yellowish-tan with all margins, carinae and pustules heavily outlined in dark brown. Structurally it is easily recognized by the rough appearance of the frons and the pronounced sinuate lateral carinae. The tegmina are more distinctly reticulate than in other species, with the veins conspicuously yellow.

*Male genitalia.* The harpago in flattened lateral view is distinctive. It appears hook-shaped rather than crescentlike, broadest through middle, but with the ventral margin less smoothly rounded.

The aedeagus is characteristically hidden by the theca, with only the tips of two sclerotized hooks visible. The theca itself is rectangular through base and has its apical flaps narrower and longer than in other species.

*Geographical distribution.* Van Duzee's catalogue lists this species form Kansas and Colorado. A large series was available for study, all of which was collected in Kansas.

### *Fitchiella melichari* (Ball) 1910

As *Naso melichari* 1910.

#### ORIGINAL DESCRIPTION

"Closely resembling *robertsoni* in size and form. Smaller, with the cephalic process less inflated at the apex. Pitchy black, without markings. Length, 3.75 mm.

Vertex short, transverse, sharply separated from the front by a distinct carina. Front broad at base, broader than in *fitchi,* tapering gradually into a long, pointed snout as seen from above. The lateral carinae expanded just before the eyes, then contracted near the middle of the process, forming a somewhat diamond-shaped compartment, beyond this regularly narrowing to the apex. Median carina obscure on the disk, becoming prominent almost foliaceous

around the extremity. As seen from the side, this protuberance is inclined at an angle of about 45 degrees, with the extremity rounded and enlarged. Pronotum large, with anterior and median carinae present. Elytra rather narrow, with a large number of irregular longitudinal veins. Abdomen narrow, the segments weakly pustulate.

*Color.* Pitchy black, the posterior margin of the eyes fulvous, the rostrum and coxae white, and often a testaceous iridescence to the front and elytra.

Described from 3 females from Arizona in the collection of the author."

*Fitchiella albifrons* Lawson 1933

COMPARATIVE NOTES

This is a small species, uniformly dark reddish-brown to black in color, except a broad longitudinal white stripe indicated on frons, pronotum and mesonotum, also base of expanded tibiae, spots on femora and a longitudinal stripe on hind tibia whitish. Tegmina with many conspicuous longitudinal veins present, claval area less pebbled than in related species.

This species belongs in the *melichari* series of the genus. Lawson states that it is separated from *melichari* by being smaller, by having the head process straighter below apically, and by having the front distinctly more concave.

*Male genitalia.* The harpago of this species is the most slender of any in the genus. It resembles a sickle blade. The theca differs from that of other species by having short, slender apical flaps, roundingly pointed.

*Location of types.* Holotype female and allotype male, collected by R. H. Beamer in the Santa Rita Mountains, Arizona, and three paratypes in the Snow Entomological Collection, University of Kansas.

*Notes on distribution.* Additional specimens have been collected by R. H. Beamer from Tucumcari Mountains, Santa Rita Mountains and Ruby, Arizona.

*Fitchiella rufipes* Lawson 1933

COMPARATIVE NOTES

This species belongs in the *melichari* series. It is distinguished on color by having the lower half of head process and first two pairs of legs down to upper third of tibiae reddish and the hind legs pale, tinged with red to near end of tibiae.

Structurally it is distinguished by having a long nasal process of which the apex is more rounded than in *albifrons* and not swollen as in other species. Size, female length, 3.25 mm. to 4 mm.; male, 2.75 mm. to 3 mm.

*Male genitalia.* The harpago in flattened lateral view is distinctive. It is shorter and broader than in other species, its greatest length not much more than twice its greatest width, the apical hook short and bluntly-pointed.

The theca has the characteristic boot-shape, with the dorsal toe of the boot less extending and roundingly pointed. The aedeagus is entirely hidden except for the prominent sclerotized hook.

*Location of types.* Holotype female and male allotype, and three paratypes in the Snow Entomological Collection, University of Kansas. A few paratypes in the collection of E. D. Ball.

*Notes on distribution.* Type locality is Zion National Park, Utah. Paratypes from Oak Creek and Granite Dell, Arizona, and Kanab and Provo, Utah. A few additional specimens on hand from Congress Junction and Yarnell, Arizona, Loyal Valley, Texas, and Three Rivers, California.

### *Fitchiella mediana* Lawson 1933

#### COMPARATIVE NOTES

A uniformly black species, which according to Lawson is close to *F. melichari,* but separatetd from that species by having the head process shorter and fore tibiae smaller. Length of female is given as 3 to 4 mm., and of male 2.5 to 3 mm.

Additional structural features are that the head process is moderately long, not swollen apically, the ventral angle sharp and cephalad of half the distance of the eye.

*Male genitalia.* Each harpago in flattened lateral view moderate in comparative length and width, widest through middle where it is slightly less than half of the length, the apical hook long and finely tapering.

The aedeagus boot-shaped, with the dorsal toe region greatly extended dorsad, before which it is deeply notched, at which point the sclerotized hook of the aedeagus emerges from between the flaps of the theca and extends almost to base of the theca.

*Location of types.* Holotype female, male allotype, and eight paratypes in the Snow Entomological Collection, University of Kansas.

*Geographical distribution.* Type locality, Sabino Canyon, Arizona. Two paratypes from Tucson, Arizona.

*Fitchiella grandis* Lawson 1933

*Original Description*

"A black species with very large, apically quadrate, head process. Length, female, 4.25 mm.

Head process very large and truncate apically, straight ventrally fully half way to eyes. Front very large and wide, extending almost to tip of head process, median carina not strong, fading out on basal third. Vertex very short. Pronotum a little over twice as wide as long, median carina distinct, with many pustules. Scutellum longer than pronotum, tricarinate, lateral portions pustulate. Elytra short and reticulated. Fore and middle tibiae not as large relatively as in *melichari*. Posterior margin of last ventral segment of female slightly produced on median half, which is slightly concave.

*Color.* Black, except for few light markings on legs.

Holotype, female, Santa Rita Mountains, Arizona, altitude 4,500 feet, September 9, 1925, A. A. Nichol. Type in Doctor Ball's collection.

This species is easily recognized by its very large, apically quadrate, head process."

*Fitchiella minor* Lawson 1933

*Original Description*

"A black species close to *F. mediana*, but with shorter head process and with reddish fore and middle tibiae. Length, female, 3.75 mm.

Head process quite short, ventral notch cephalad of middle of distance to eye. Front with median carina fading out at base. Vertex very short. Pronotum about twice as wide as long, with strong median carina and many pustules. Scutellum longer than pronotum, with three carinae and many lateral pustules. Elytra short and reticulated. Fore and middle tibiae distinctly smaller than in *mediana*. Last ventral segment of female triangular; posterior margin produced and truncate on median half.

*Color.* Black, with suggestion of white stripe along sutural margin of elytra. Fore and middle tibiae reddish. Holotype, female, Tucson, Ariz., March 10, 1931, E. D. Ball. Type in Doctor Ball's collection.

This species has the shortest head process in the series of closely related species composed of this, *F. mediana*, and *F. melichari* (Fig. 5.), the last having the longest process. This spicies also has the smallest fore tibiae of the three, with *melichari* (fig. 5a) having the largest."

## ADDENDUM

### *Thionia acuta* n. sp.

= *Thionia naso* Doering not Fowler. See *University of Kansas Science Bulletin*, Vol. XXV, No. 20, June 1, 1938.

At the time of the revision of the genus *Thionia*, published in Part II of this paper (1938), the writer did not have access to the type of *Thionia naso* Fowler. A series of specimens from Concan, Texas, was, therefore, wrongly designated as Fowler's species, based on a comparison made by Doctor Ball with the single type. Mr. Paul Oman, of the National Museum, recently pointed out to the present writer that in his opinoin the Concan material could not be Fowler's species. With the addition of the Ball collection to the National Museum collection, the type of *naso* became available for study. Subsequent comparison of the Concan material with the latter proves conclusively that the Concan material is not *naso* Fowler and is, therefore, a new species. The name *acuta* has been assigned to it. For the complete description of *acuta* n. sp. see the description of *Thionia naso*, Fowler, p. 463, *University of Kansas Science Bulletin*, Vol. XXV, No. 20, June 1, 1938.

Type specimens are: Male holotype, female allotype, eight female paratypes and three male paratypes, taken by Mr. Paul Oman at Concan, Texas, June 4, 1933. These types are in the National Museum. Two male paratypes and two female paratypes taken by R. H. Beamer, at Concan, Texas, on June 6, 1936.

### *Dictyssa doeringae* Ball

Ball, E. D. Some New Issids with Notes on Others (Homoptera-Fulgoridae). *Proc. Biol. Soc. of Wash.*, 49:155-158, 1936.

= *Dictyssa balli* Doering. See *University of Kansas Science Bulletin*, Vol. XXIV, No. 17, July 15, 1936.

An amusing exchange of names between Doctor Ball and the writer was made in regard to this species. Both recognized this material as new at about the same time and after comparing notes on the subject, Doctor Ball graciously told the writer to describe it in the present monograph. Apparently later he forgot this conversation and described it himself in a short paper dealing with a few new Issids which, only because of the delayed mailing date of the *Kansas Science Bulletin*, appeared in actual distribution before the latter. Ball's species, therefore, has priority over *Dictyssa balli* Doering.

*Dictyssa monroviana* Doering

A notation in regard to additional paratypes for this species should be made. A series of paratypes from Del Mar, California, collected by Paul Oman, is in the National Museum at Washington, D. C.

## THE GENUS NEAETHUS

During the summer of 1938, Dr. R. H. Beamer and the Kansas University biological survey party, while collecting in California, made a concentrated study of the insect fauna of the various species of the *manzanita* plant. The collections were made by sweeping the bushes and, therefore, of course, are not an absolute check in regard to host relationship as specimens might easily move from one bush to another during the disturbance of sweeping. Nevertheless, in regard to the genus *Neaethus* it did bring to light three more new species which were not included in Part II of this monograph and apparently offers partial explanation, at least, as to the great numbers of species in this genus with their slight variations. Like the genus *Clastoptera* in the family Cercopidae, which showed species variation coinciding with the various varieties of oak in the southwestern mountains, the genus *Neaethus* apparently has spread out in the same manner following the evolution of manzanita plant.

*Neaethus unicus* n. sp.

*Size.* Length of body to tip of tegmen of female, 4.95 mm.; of male, 4.5 mm. Length of tegmen of female, 4.05 mm.; of male, 3.6 mm. Width of tegmen, 2.25 mm.

*Color.* General color stramineous. Eyes brown. Lateral disks of frons light brown through middle. Postclypeus with a broad median stripe. Pleural segments washed in brown. Middle segments of abdomen blackish-brown in sharp contrast to yellow apical segments. Mesal margins of ovipositor dark brown. Coxae and femora of hind legs fuscous. Claws and tips of spines on legs black. Tegmina with cells milky, longitudinal veins yellow, cross-veins dark brown.

*Structural characteristics.* Vertex, greatest width four times length at middle. Greatest width of eye one-fourth total width of head. Length of pronotum at middle twice the same length of vertex, anterior margin greatly elevated, a transverse depressed line across middle, disk depressed. Disk of mesonotum depressed through middle, a faint median carina indicated. Frons one-fifth longer than width at dorsal margin. Length of frons and postclypeus at

middle approximately equal. Postclypeus with no median carina. Tegmina ovate, greatest width in line with apex of clavus, width at this point slightly less than two-thirds of length, cells large, veins thick and elevated; vein $Sc_1$ running almost half length of tegmen, few cross veinlets in $Sc_1$ cell; vein $Sc_2$ and R each branching once; vein M apparently five-branched; vein $Cu_1$ branched just back of middle. Hind wings unique for the genus, being as long as the body.

*Male genitalia.* Anal flap of female without prongs, only slightly indented at middle of posterior margin. Each harpago, in flattened lateral view, crescent-shaped, slender, the dorsal margin deeply concave through middle, the posterior third slightly deflexed inwardly, below this a small, external ventrad-directed hook.

Aedeagus and theca unique. From a right view the theca is conspicuous, being a semimembranous sleeve covering half the aedeagus at base, beyond which the dorsal portion extends caudad as a flat lobe, narrowing finally into a slender, fingerlike apex. On this side the distal half of the aedeagus bears a long, flattened, external, heavily sclerotized process, lying closely adpressed to the side and its tip is bulbous. From a left view the theca is shorter and its posterior margin is obliquely truncate. The apical portion of the aedeagus is the same as on the left side. Near the base are two additional pronglike hooks, which are exposed for half their length beyond the thecal margin, the ventral one of the two being unique by having a lateral, slightly curved, side prong.

*Comparative notes.* This species is readily distinguished from other members of the genus by the hind wings, which extend as far as the apex of the abdomen. No other species has wings of this length. In most species the wings are reduced to mere scales, except for three species, *perlucidus*, *fragosus* and *grossus,* where they extend to the tip of the tegmina.

*Location of types.* Holotype male, allotype female, and 61 paratypes taken by R. H. Beamer from Lempoc, California, August 6, 1938. They were swept from *Arctostaphylos pechoensis viridissima* East. Types and most of the paratypes in the Snow Entomological Collection at the University of Kansas.

*Neaethus bicornis* n. sp.

*Size.* Length of body from apex of head to tip of tegmen, female, 4.1 mm. to 4.29 mm., male, 3.75 mm. to 4.18 mm. Length of tegmen, female, 3.7 mm.; male, 3.08 mm. Greatest width of tegmen, 1.98 mm. to 2.2 mm.

*Color.* This species has the typical *Neaethus* ground coloring of golden tan, but has enough dark mottling to give it a much duskier appearance than many species have. Eyes reddish-brown, cross-barred with yellow crescents. Thin carinate margins of vertex dark brown, a thin light yellow longitudinal stripe down middle and continued across pro- and mesonotum. On vertex a pair of slender brown bars against elevated posterior margin. On pronotum brown markings distributed as follows: two round depressed spots in center of disk, a large area back of each eye, a cluster of about nine darker small round dots partly covering this spot and on disk mesad to it. The extreme lateral corners of mesonotum and two pseudo round spots on disk dark brown. Frons dusky brown except the elevated median carina, a longitudinal row of roundish spots just mesad of outer borders and a spread-eagle spot on ventral half. Postclypeus dark brown on disk, sides light at base, mottled near apex; anteclypeus with elevated median carina light, a thin brown stripe on each side next to carina, rest mottled. Gena dusky around eye, lighter below. Segments of body and legs smoky, mottled at various points.

*Structural characteristics.* Vertex narrow, anterior margin twice wider than one lateral margin. Width of eye one-half that of vertex. Pronotum at middle equal in length to one lateral margin of vertex. Mesonotum with middle half depressed, lateral carinae distinct, middle carina only slightly indicated. Frons with a prominent median carina extending three-fourths its length, lateral margins less elevated than in some species, almost parallel-sided. Clypeus and frons on median line equal in length, the postclypeus invaginated into frons for about one-fifth of the greatest length of latter. Postclypeus with a distinct median carina. Tegmina quadrangular rather than hemispherical in shape, greatest width in line with apex of clavus, at which point it is five-eighths of its length; veins thick, cells large; vein $Sc_1$ widely separated from costal margin, costal cell area reflexed, venation usually of the following pattern: $Sc_2$ with two main branches, R two main branches, M three main branches, $Cu_1$, two-branched, the branches of which unite at apex, then run ventrad as a single vein which joins a branch of M, making a partial ambient vein at apex. Hind wings reduced to a mere scale.

*Male genitalia.* This species is separated easily from all other species in the genus by the anal flap (tenth abdominal segment) which has the posterior ventral margin greatly extended into two long prongs at the side with a broad space between.

Each harpago in flattened lateral view unusually broad, its outline subtriangular, the greatest width being across the apical fourth and the dorso-apical region bearing a large external hook which is unusually broad at base but tapers to a short recurved hook at apex.

The aedeagus on the left side is covered by the sleevelike theca for half its length. At the base, almost entirely covered by the theca except the extreme tip, the aedeagus bears a hook which is bifurcate, with the dorsal fork abbreviated. Near the middle it bears a conspicuous, well-sclerotized, process which is somewhat sinuate and has its slender apex bent slightly ventrad. Near base of apical third is a short, pointed, dorsad directed hook and the extreme apex of the aedeagus ends in a sclerotized fine point.

On the right side the posterior dorsal extension of the theca is more evident and a dorsal, sharply pointed, sclerotized process is plainly visible.

*Comparative notes.* This species resembles *Neaethus similis* and *Neaethus vitripennis*. From *similis* it is distinguished by its much smaller size, narrower vertex and the male genitalia. From *vitripennis* it is distinguished by its smaller size, its general body coloring, which is mainly fuscous, and its milky tegmina with dark veins, while *vitripennis* has golden yellow body with transparent yellow tegmina. The anal flap is unique for the genus due to the presence of the bifurcate apex, with the prongs or horns much longer than in *vitripennis* or any other species. Differences in the aedeagal structure can readily be seen by comparison of the drawings.

*Location of types.* Holotype male, collected at Mt. Tamalpais, California, August 15, 1938, by R. H. Beamer. Female allotype, same data. Thirty-five paratypes same data. Thirty-two paratypes, collected August 16, 1938, by R. H. Beamer, at Santa Rosa, California. These specimens were swept from *Arctostaphylos manzanita* Parry.

Types and most of the paratypes in the Snow Entomological Collection, University of Kansas.

*Neaethus consuetus* n. sp.

*Size.* Length of body from apex of head to tip of tegmen, female, 4.51 mm. to 5.28 mm.; male, 4.51 mm. Length of tegmen, female, 4.07 mm. to 4.4 mm.; male, 3.85 mm. Greatest width of tegmen, 2.43 to 2.97 mm.

*Color.* Females similar to *bicornis*, in general color, males less fuscous. Eyes tan, uniformly cross-barred with five conspicuous maroon crescents. Female coloring as follows: Vertex and thorax

from above golden-yellow, a faint median narrow stripe lighter, the anterior margin of vertex and three spots in each lateral half reddish-brown, a darker brown spot on pronotum arm posterior to eye, mesad of which is a cluster of about nine minute brown spots and a depressed round brown spot. Each lateral corner of mesonotum dark brown, forming with the dark spot on pronotum a conspicuous lateral stripe. Frons curiously mottled, the median carina and approximately the outer fourth cream-colored, disk on each side of the median carina light-brown, margined with dark reddish-brown, which thus forms a narrow dark stripe running lengthwise down center of each lateral half, the lateral pale stripe irregularly speckled with dark brown. Postclypeus yellow, with a longitudinal reddish-brown stripe on each side of yellow median stripe. Genae uniform yellow, a brownish spot on lateral area of postclypeus. Body and legs fuscous, some yellow along borders of segments. Body coloring of males golden-tan, scarcely any fuscous or darker markings present. Tegmina of both sexes similar, cells semitranslucent, veins fuscous, cross-veins of clavus and cell $Cu_2$ almost black, sometimes a conspicuous black spot at extreme apex of this cell.

*Structural characteristics.* Vertex broader than in *bicornis* n. sp., its anterior margin approximately one-sixth wider than one lateral margin, the lateral margins slightly converging anteriorly. Pronotum at middle equal in length to one lateral margin. Mesonotum depressed through middle, carinae absent or faintly indicated. Frons elongate, width at posterior or dorsal margin slightly more than two-thirds greatest length, median length equal to length of postclypeus, lateral margins parallel, less elevated than in some species. Postclypeus invaginated into frons for only about one-sixth the length of latter, a prominent median carina present. Tegmina quadrangular, greatest width just anterior to apex of clavus, at this point width about five-eighths of its length. Veins thick, vein $Sc_1$ widely separated from costal margin, costal cell area reflexed, venation usually of the following pattern: $Sc_2$ with two or three main branches, R, with two branches, M, four or five branches, $Cu_1$, two branches with branches united at apex. Hind wings reduced to a mere scale.

*Male genitalia.* Posterior ventral margin of anal flap forked with the length of the prongs nearer that of *maculatus* than any other group.

Each harpago in flattened lateral view, also resembling that of *maculatus* in general shape, has the apical region truncate and is

much broader through this area than at base. The external apical hook is unique for this species, being very broad across base and then narrowing to a very small pointed recurved apex.

The aedeagal structure more closely resembles *maculatus* than other species. The theca for the most part is a long slender sleeve, which on the right side ends truncately at base of approximate apical fourth of aedeagus. On the left side the theca is abbreviated at about middle of aedeagus except for a posterior dorsal extension which runs to base of apical sixth and whose margins partially fold together, making the flap appear bilobed at tip. On the right side only the recurved apical portion of the aedeagus extends beyond the thecal margin and only the apical half of a lateral, well-sclerotized process is visible. On the left side approximately half the aedeagus is exposed and two processes are visible, one of which arises under the theca near middle and is a prominent, sinuate, flattened process, which ends in a small, recurved hook and extends posteriorly as far as the tip of the thecal process; the second arises at about base of apical third, is closely adpressed to the aedeagus, is sharply tapered and ends slightly beyond the thecal tip. Through the semimembranous theca can be seen a short, more bluntly pointed process with apex directed dorsad.

*Comparative notes.* The genitalia place this species near *maculatus*. The main differences in these structures are that the thecal flap is more slender and that the prominent right aedeagal hook is longer and more curved in *consuetus* than in *maculatus,* while the second visible thecal hook on the right in the latter is short and arises near middle, in place of being a long pointed process, situated nearer the apex as in *consuetus*.

Externally, these two species are approximately the same size and have similarly shaped tegmina. They are readily distinguished by color. The tegmina of *maculatus* are golden-tan, crossed with two oblique fuscous bands, and the veins are less thick and uniformly light. The general body coloring is likewise uniformly golden, with little darker markings. In *consuetus* the females especially have fuscous bodies, and the tegmina are milky, semiopaque, with heavy dark veins and no oblique brown stripes.

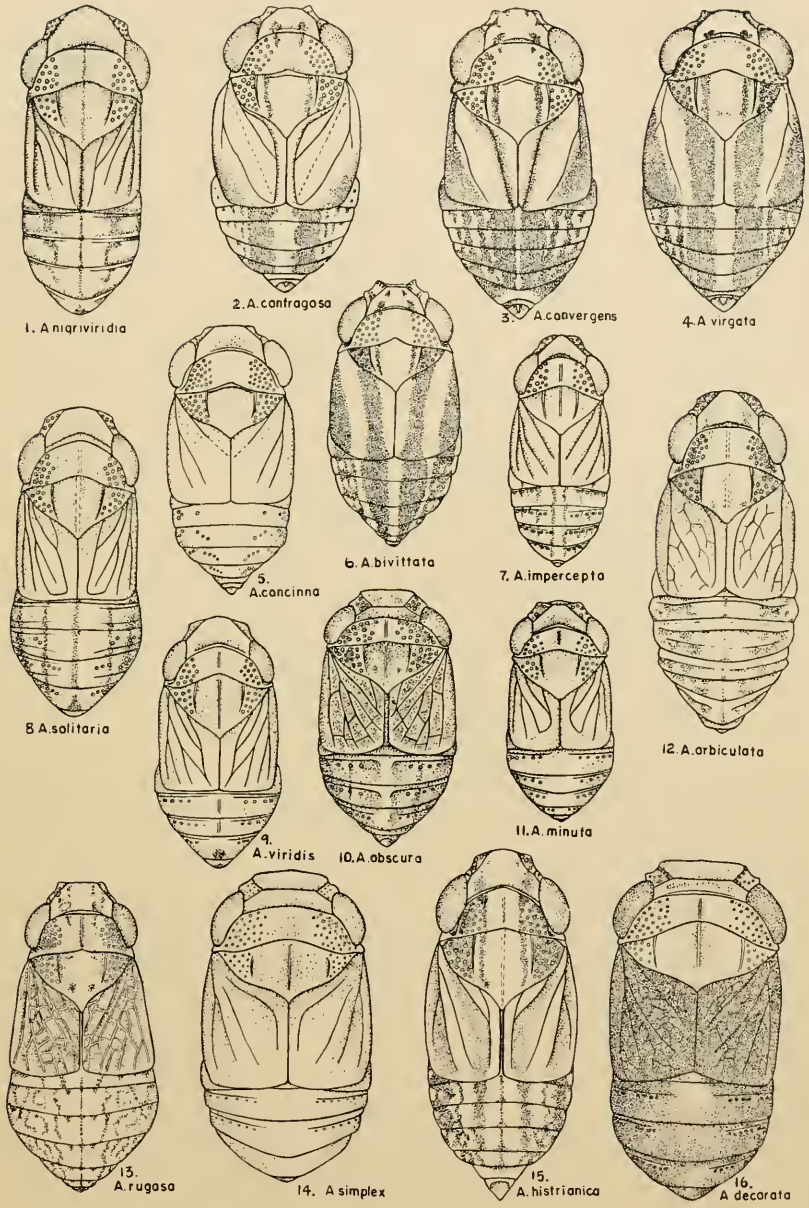
*Distribution of types.* Male holotype, female allotype, five female and six male paratypes taken August 13, 1938, at Santa Cruz, California, by R. H. Beamer, on *Arctostaphylos tomentosa* Pur. and *Arctostaphylos sensitiva* Jap.

## PLATE XIII

FIG.

1. Dorsal view of *Apheloncma nigriviridia* Ball.
2. Dorsal view of *Apheloncma confragosa* n. sp.
3. Dorsal view of *Apheloncma convergens* Bunn.
4. Dorsal view of *Apheloncma virgata* n. sp.
5. Dorsal view of *Apheloncma concinna* n. sp.
6. Dorsal view of *Apheloncma bivittata* Ball.
7. Dorsal view of *Apheloncma impercepta* n. sp.
8. Dorsal view of *Apheloncma solitaria* Ball.
9. Dorsal view of *Apheloncma viridis* Doz.
10. Dorsal view of *Apheloncma obscura* Van Duzee.
11. Dorsal view of *Apheloncma minuta* Bunn.
12. Dorsal view of *Apheloncma orbiculata* Ball.
13. Dorsal view of *Apheloncma rugosa* (Ball).
14. Dorsal view of *Apheloncma simplex* Uhler.
15. Dorsal view of *Apheloncma histrionica* Stal.
16. Dorsal view of *Apheloncma decorata* (Van Duzee).

# PLATE XIII

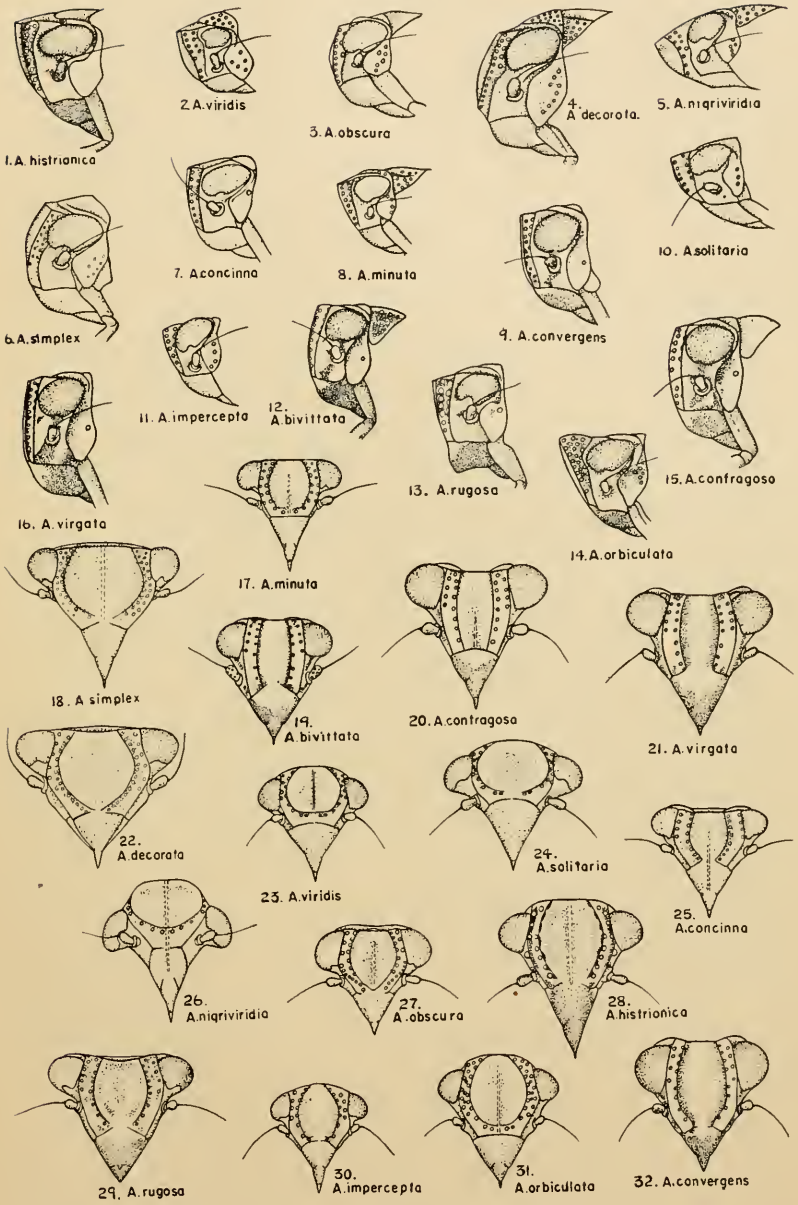

1. A nigriviridia
2. A. confragosa
3. A. convergens
4. A virgata
5. A. concinna
6. A. bivittata
7. A. impercepta
8 A. solitaria
9. A. viridis
10. A. obscura
11. A. minuta
12. A. orbiculata
13. A. rugosa
14. A simplex
15. A. histrianica
16. A decorata

## PLATE XIV

FIG.

1. Lateral view of head of *Aphelonema histrionica* Stal.
2. Lateral view of head of *Aphelonema viridis* Doz.
3. Lateral view of head of *Aphelonema obscura* Van Duzee.
4. Lateral view of head of *Aphelonema decorata* (Van Duzee).
5. Lateral view of head of *Aphelonema nigriviridia* Ball.
6. Lateral view of head of *Aphelonema simplex* Uhler.
7. Lateral view of head of *Aphelonema concinna* n. sp.
8. Lateral view of head of *Aphelonema minuta* Bunn.
9. Lateral view of head of *Aphelonema convergens* Bunn.
10. Lateral view of head of *Aphelonema solitaria* Ball.
11. Lateral view of head of *Aphelonema impercepta* n. sp.
12. Lateral view of head of *Aphelonema bivittata* Ball.
13. Lateral view of head of *Aphelonema rugosa* (Ball).
14. Lateral view of head of *Aphelonema orbiculata* Ball.
15. Lateral view of head of *Aphelonema confragosa* n. sp.
16. Lateral view of head of *Aphelonema virgata* n. sp.
17. Cephalic view of head of *Aphelonema minuta* Bunn.
18. Cephalic view of head of *Aphelonema simplex* Uhler.
19. Cephalic view of head of *Aphelonema bivittata* Ball.
20. Cephalic view of head of *Aphelonema confragosa* n. sp.
21. Cephalic view of head of *Aphelonema virgata* n. sp.
22. Cephalic view of head of *Aphelonema decorata* (Van Duzee).
23. Cephalic view of head of *Aphelonema viridis* Doz.
24. Cephalic view of head of *Aphelonema solitaria* Ball.
25. Cephalic view of head of *Aphelonema concinna* n. sp.
26. Cephalic view of head of *Aphelonema nigriviridia* Ball.
27. Cephalic view of head of *Aphelonema obscura* Van Duzee.
28. Cephalic view of head of *Aphelonema histrionica* Stal.
29. Cephalic view of head of *Aphelonema rugosa* (Ball).
30. Cephalic view of head of *Aphelonema impercepta* n. sp.
31. Cephalic view of head of *Aphelonema orbiculata* Ball.
32. Cephalic view of head of *Aphelonema convergens* Bunn.

## PLATE XIV

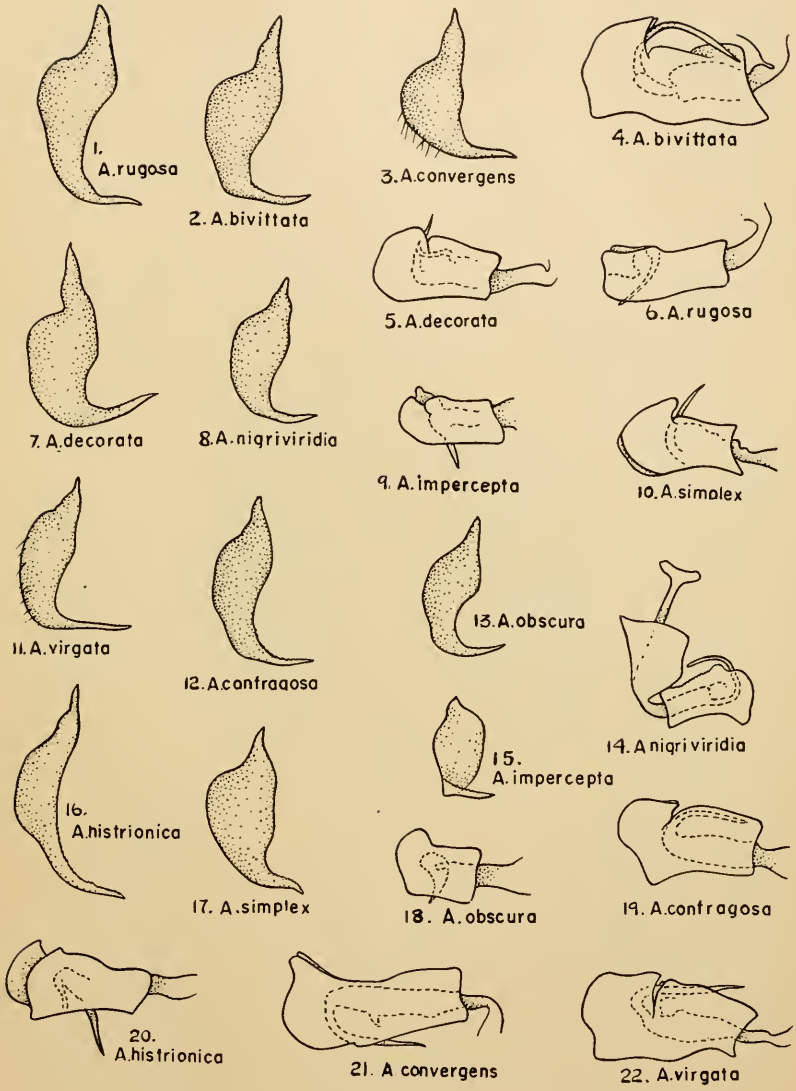

1. A. histrionica
2. A. viridis
3. A. obscura
4. A. decorata.
5. A. nigriviridis
6. A. simplex
7. A. concinna
8. A. minuta
9. A. convergens
10. A. solitaria
11. A. impercepta
12. A. bivittata
13. A. rugosa
14. A. orbiculata
15. A. confragosa
16. A. virgata
17. A. minuta
18. A. simplex
19. A. bivittata
20. A. contragosa
21. A. virgata
22. A. decorata
23. A. viridis
24. A. solitaria
25. A. concinna
26. A. nigriviridis
27. A. obscura
28. A. histrionica
29. A. rugosa
30. A. impercepta
31. A. orbiculata
32. A. convergens

## PLATE XV

FIG.

1. Lateral view of harpago of *Aphelonema rugosa* (Ball).
2. Lateral view of harpago of *Aphelonema bivittata* Ball.
3. Lateral view of harpago of *Aphelonema convergens* Bunn.
4. Lateral view of aedeagus and theca of *Aphelonema bivittata* Ball.
5. Lateral view of aedeagus and theca of *Aphelonema decorata* (Van Duzee).
6. Lateral view of aedeagus and theca of *Aphelonema rugosa* (Ball).
7. Lateral view of harpago of *Aphelonema decorata* (Van Duzee).
8. Lateral view of harpago of *Aphelonema nigriviridia* Ball.
9. Lateral view of aedeagus and theca of *Aphelonema impercepta* n. sp.
10. Lateral view of aedeagus and theca of *Aphelonema simplex* Uhler.
11. Lateral view of harpago of *Aphelonema virgata* n. sp.
12. Lateral view of harpago of *Aphelonema confragosa* n. sp.
13. Lateral view of harpago of *Aphelonema obscura* Van Duzee.
14. Lateral view of aedeagus and theca of *Aphelonema nigriviridia* Ball.
15. Lateral view of harpago of *Aphelonema impercepta* n. sp.
16. Lateral view of harpago of *Aphelonema histrionica* Stal.
17. Lateral view of harpago of *Aphelonema simplex* Uhler.
18. Lateral view of aedeagus and theca of *Aphelonema obscura* Van Duzee.
19. Lateral view of aedeagus and theca of *Aphelonema confragosa* n. sp.
20. Lateral view of aedeagus and theca of *Aphelonema histrionica* Stal.
21. Lateral view of aedeagus and theca of *Aphelonema convergens* Bunn.
22. Lateral view of aedeagus and theca of *Aphelonema virgata* n. sp.

## PLATE XV

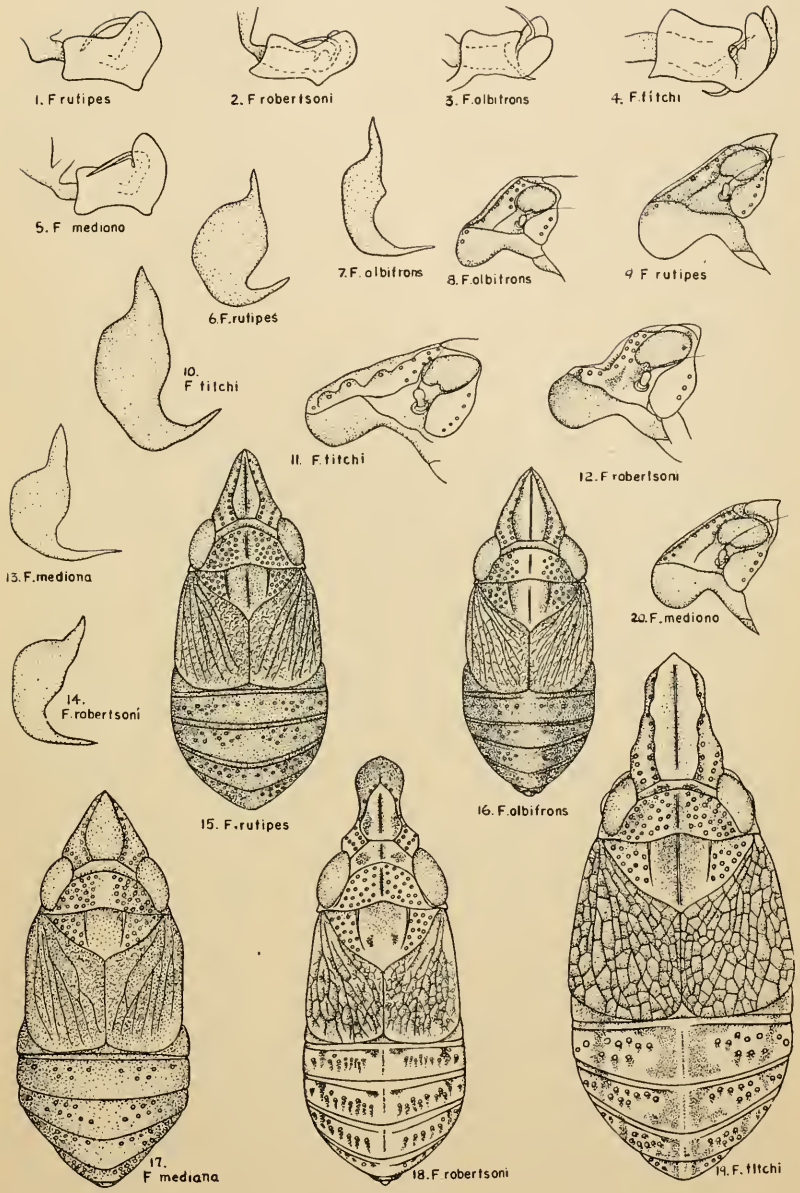

1. A. rugosa
2. A. bivittata
3. A. convergens
4. A. bivittata
5. A. decorata
6. A. rugosa
7. A. decorata
8. A. nigriviridia
9. A. impercepta
10. A. simplex
11. A. virgata
12. A. confragosa
13. A. obscura
14. A. nigriviridia
15. A. impercepta
16. A. histrionica
17. A. simplex
18. A. obscura
19. A. confragosa
20. A. histrionica
21. A. convergens
22. A. virgata

## PLATE XVI

FIG.

1. Lateral view of aedeagus and theca of *Fitchiella rufipes* Lawson.
2. Lateral view of aedeagus and theca of *Fitchiella robertsoni* Fitch.
3. Lateral view of aedeagus and theca of *Fitchiella albifrons* Lawson.
4. Lateral view of aedeagus and theca of *Fitchiella fitchi* Melichar.
5. Lateral view of aedeagus and theca of *Fitchiella mediana* Lawson.
6. Lateral view of harpago of *Fitchiella rufipes* Lawson.
7. Lateral view of harpago of *Fitchiella albifrons* Lawson.
8. Lateral view of head of *Fitchiella albifrons* Lawson.
9. Lateral view of head of *Fitchiella rufipes* Lawson.
10. Lateral view of harpago of *Fitchiella fitchi* Melichar.
11. Lateral view of head of *Fitchiella fitchi* Melichar.
12. Lateral view of head of *Fitchiella robertsoni* Fitch.
13. Lateral view of harpago of *Fitchiella mediana* Lawson.
14. Lateral view of harpago of *Fitchiella robertsoni* Fitch.
15. Dorsal view of *Fitchiella rufipes* Lawson.
16. Dorsal view of *Fitchiella albifrons* Lawson.
17. Dorsal view of *Fitchiella mediana* Lawson.
18. Dorsal view of *Fitchiella robertsoni* Fitch.
19. Dorsal view of *Fitchiella fitchi* Melichar.

## PLATE XVI

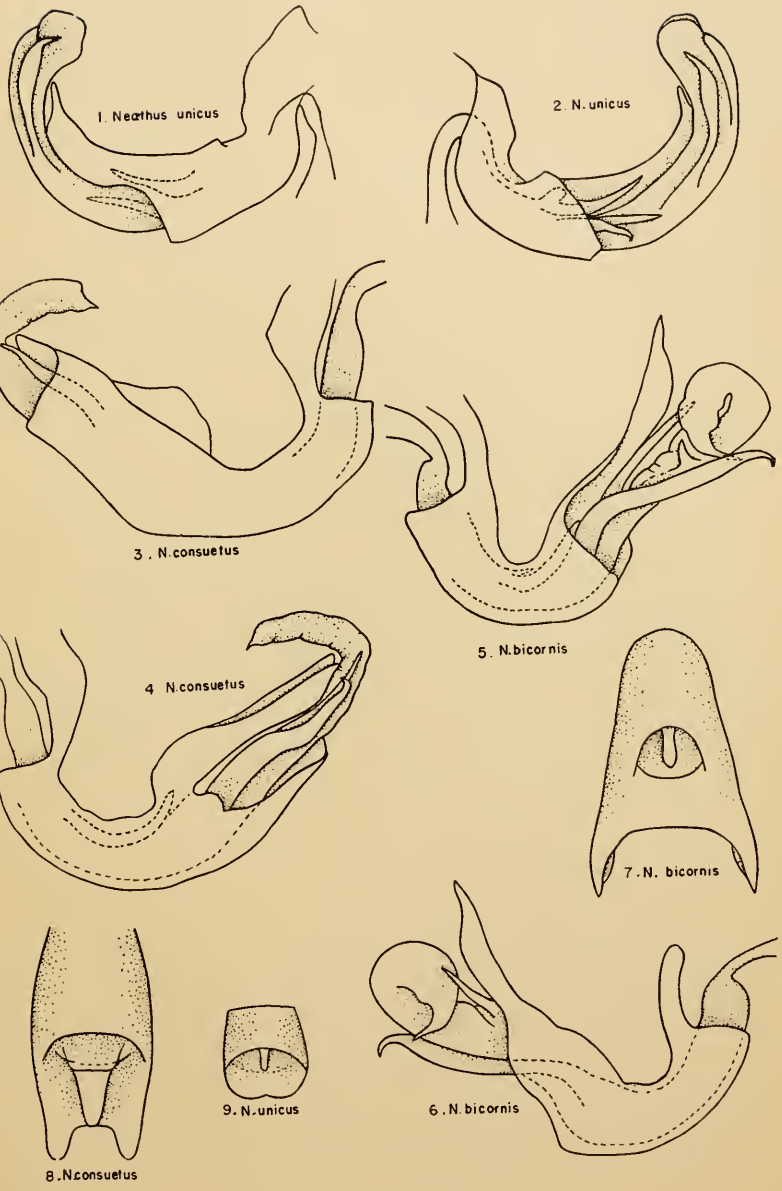

1. F rutipes
2. F robertsoni
3. F.albitrons
4. F.titchi
5. F mediana
6. F.rutipes
7. F. albitrons
8. F.albitrons
9 F rutipes
10. F titchi
11. F.titchi
12. F robertsoni
13. F.mediana
14. F.robertsoni
15. F.rutipes
16. F.albifrons
17. F mediana
18. F robertsoni
19. F. titchi
20. F. mediana

## PLATE XVII

FIG.

1. Lateral right view of aedeagus and theca of *Neaethus unicus* n. sp.
2. Lateral left view of aedeagus and theca of *Neaethus unicus* n. sp.
3. Lateral right view of aedeagus and theca of *Neaethus consuetus* n. sp.
4. Lateral left view of aedeagus and theca of *Neaethus consuetus* n. sp.
5. Lateral left view of aedeagus and theca of *Neaethus bicornis* n. sp.
6. Lateral right view of aedeagus and theca of *Neaethus bicornis* n. sp.
7. Flattened dorsal view of tenth abdominal segment of *Neaethus bicornis* n. sp.
8. Flattened dorsal view of tenth abdominal segment of *Neaethus consuetus* n. sp.
9. Flattened dorsal view of tenth abdominal segment of *Neaethus unicus* n. sp.

## PLATE XVII

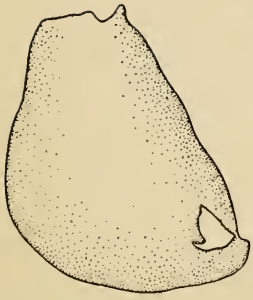

1. Neœthus unicus
2. N. unicus
3. N. consuetus
5. N. bicornis
4. N. consuetus
7. N. bicornis
9. N. unicus
6. N. bicornis
8. N. consuetus

## PLATE XVIII

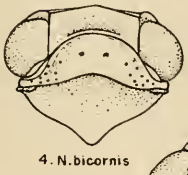
FIG.

1. Lateral view of harpago of *Neaethus consuetus* n. sp.
2. Lateral view of harpago of *Neaethus unicus* n. sp.
3. Lateral view of harpago of *Neaethus bicornis* n. sp.
4. Dorsal view of head and thorax of *Neaethus bicornis* n. sp.
5. Dorsal view of head and thorax of *Neaethus consuetus* n. sp.
6. Dorsal view of head and thorax of *Neaethus unicus* n. sp.
7. Lateral view of *Neaethus bicornis* n. sp.
8. Lateral view of *Neaethus consuetus* n. sp.
9. Lateral view of *Neaethus unicus* n. sp.

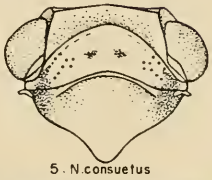
# PLATE XVIII



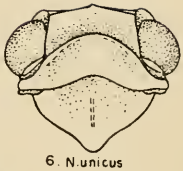
1. Neathus consuetus



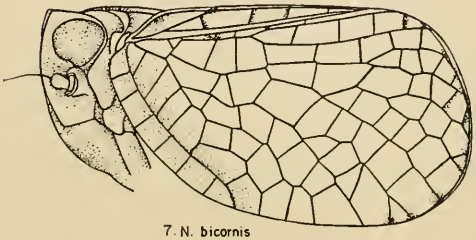
4. N. bicornis



5. N. consuetus

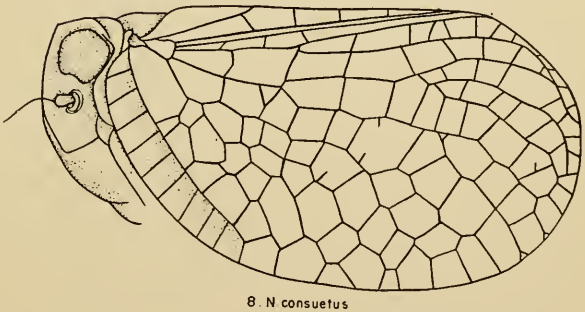


6. N. unicus



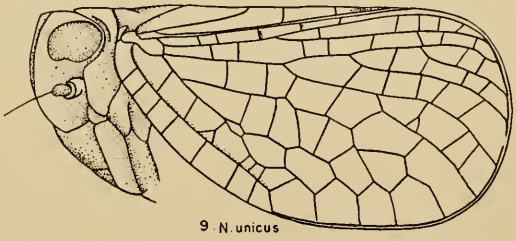
7. N. bicornis

2. N. unicus



8. N. consuetus

3. N. bicornis



9. N. unicus

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IX.....Nos. 1-21, weight, 54 ounces.

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XII.....Nos. 1-2, weight, 19 ounces.

XIII.....Pt. I, Nos. 1-9, weight, 12 ounces. Pt. II, Nos. 10-15, weight, 10 ounces.

XIV.....Nos. 1-21, weight, 34 ounces.

XV.....Nos. 1-6, weight, 18 ounces.

XVI.....Nos. 1-6, weight, 14 ounces.

XVII.....Pt. I, No. 1, weight, 18 ounces. Pt. II, Nos. 2-7, weight, 8 ounces.

XVIII.....Nos. 1-13, weight, 38 ounces.

XIX.....Pt. I, Nos. 1-7, weight, 6 ounces. Pt. II, Nos. 8-14, weight, 16 ounces.

XX.....Pt. I, Nos. 1-6, weight, 11 ounces. Pt. II, Nos. 7-21, weight, 15 ounces.

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